APPENDIX S

PROPOSED

LEV III Economic Analysis

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I. Introduction

The proposed Advanced Clean Cars (ACC) program aims to reduce future criteria and greenhouse gas emissions by requiring new vehicles sold to meet newer more stringent emissions standards. Several economic factors and phenomena will influence the ultimate emissions reductions that are achieved by the program. Additionally, the program may yield both private to vehicle purchasers as well as societal benefits to all of California and beyond. This chapter provides additional details on the methods and analyses used to assess the potential economic impacts and benefits of the proposed ACC program.

II. The Rebound Effect: Effect of the Regulation on Vehicle Miles Traveled

The new vehicle performance standard regulation is designed, in part, to reduce emissions of GHGs. As discussed in Section IX of the ISOR, many of the technologies that reduce emissions of GHGs also serve to lower the operating costs of the vehicle. The possibility that this decline in operating costs induces additional energy use that cuts into the benefits of the policy is often known as the rebound effect. This section discusses the rebound effect of the proposed Advanced Clean Cars program and estimates the magnitude of the rebound effect in California based on the best available literature. The projection of the future rebound effect is then translated to the change in vehicle miles traveled that would be implied as a result of the various policy scenarios, which are incorporated in the statewide emissions inventories described in Appendix T.

A. Background

The concept of a rebound effect from improving energy efficiency has a long history, and has been discussed in the context of a variety of energy-using durable goods, including vehicles. The discussion here is focused on what the rebound effect *from the regulation* will be, rather than the rebound effect from improvements in energy efficiency in the economy as a whole over time.

The rebound effect is composed of three channels. The *direct rebound effect* refers to the energy use and emissions from the additional driving due to a decrease in the operating cost of a vehicle. The direct rebound effect occurs through consumers substituting from other purchases to driving and from consumers using some of the saved income from the lower operating cost to pay to drive more. The *indirect rebound effect* refers to the energy use and emissions from the purchase of other energy-intensive goods and services using the income that becomes available when less is spent on driving. Thirdly, if enough vehicles simultaneously use less gasoline per mile of driving, then the global demand for gasoline would decline, leading to a lower global price of gasoline. If this occurs, the quantity of gasoline demanded could increase in other regions and countries outside of California. This effect is often known as the *macroeconomic* or *general-equilibrium* rebound effect.

All three channels for the rebound effect provide benefits to consumers. For example, consumers benefit from driving more. Consumers also benefit from purchasing additional goods and services using the income that becomes available when less is spent on driving. Similarly, consumers benefit from lower gasoline prices. On the other hand, the rebound effect reduces the energy savings from the policy. When the environmental damages from the reduced energy savings are taken into account, the rebound effect may or may not be consumer welfare-improving. In this analysis, we will not quantify the welfare benefits of the rebound effect, but will attempt to quantify the reduced energy savings due only to the direct rebound effect. As will be discussed in the next section, there is very little evidence on the indirect rebound effect and macroeconomic rebound effect, and thus we determined that these two other channels are too speculative to quantify without further evidence.

A1. Estimates of the Rebound Effect

How large is the rebound effect? Quantifying the rebound effect has been the subject of an extensive academic literature. A variety of different definitions of the rebound effect have been used in the literature, often leading to different estimates of the range of the rebound effect. Ideally, for a policy analysis of new vehicle performance standards, we would like to have a reliable estimate of the additional energy use *solely* from the new regulation due to the consumer responses to the decrease in operating costs described in Section IX. To calculate this, we would need to know the difference in energy use in a policy scenario where there is no rebound effect, and a scenario where there is a rebound effect. This exact expression has yet to be quantified by any of the studies in the academic literature.

The academic literature has instead focused almost entirely on the direct rebound effect resulting from more general changes in operating costs. Accordingly, our review of the estimates of the rebound effect in the literature focuses on the direct rebound effect. There is very limited evidence on the magnitude of the indirect rebound effect and macroeconomic rebound effect in the literature. Druckman et al. (2011) point out that the magnitude of the indirect rebound effect in the United Kingdom depends greatly on the greenhouse gas intensity of the goods and services purchased using the addition income that becomes available when less is spent on driving. However, at this point in time, there is no solid evidence to indicate that it is a significant factor in the United States or California.

Similarly, the only evidence on the macroeconomic rebound effect is also from the United Kingdom. Barker et al. (2007) use a computable general equilibrium model of the United Kingdom economy to find a 19 percent macroeconomic rebound effect. This estimate would imply that 19% of the energy savings from improved energy efficiency in the economy are lost due to increased energy-using activity. It is not the rebound effect of a new vehicle performance standard, and thus cannot be interpreted as such.

The direct rebound effect of new vehicle performance standards is conceptually based on the amount of additional driving when the standards are increased and the cost of driving decreases. The cost of driving is a function of both vehicle technology and the price of fuel. Thus, most researchers have focused on estimating the elasticity of driving with respect to the cost of driving, assuming that changes in either variable will result in similar responses. This elasticity is defined as the percentage change in vehicle-miles-traveled (VMT) over the percentage change in the cost per mile of driving:

$$Elasticity\ of\ VMT\ with\ respect\ to\ cost\ per\ mile\ of\ driving = \frac{\%\ change\ in\ VMT}{\%\ change\ in\ cost\ per\ mile\ of\ driving}.$$

For example, suppose the elasticity of VMT with respect to the cost per mile of driving is estimated to be -0.1. This implies that if we decrease the cost per mile of driving by 10%, VMT will increase by 1%.

While the elasticity of VMT with respect to the cost per mile of driving is the most common elasticity researchers have used to estimate the rebound effect, it is by no means the only elasticity that researchers have called “the rebound effect.” As discussed earlier, the cost per mile of driving will depend on both the vehicle itself and the price of fuel. Some researchers estimate the elasticity of driving with respect to *the gasoline price* specifically. If consumers respond to changes in the gasoline price in the same way that they respond to changes in the cost per mile of driving and the change in the cost per mile of driving comes about only from a change in the gasoline price, then these two elasticities must be identical. All of the studies in the literature estimating the elasticity of VMT with respect to the cost per mile of driving use changes in gasoline prices to estimate the relationship between VMT and the cost per mile of driving. Thus, the literature review here also examines papers estimating the elasticity of VMT with respect to the price of gasoline. Of course, in the case of new vehicle performance standards, the change in the cost per mile of driving does not come about from a change in the gasoline price; thus, the elasticities with respect to fuel price are presented here only for purposes of comparison.

Table II-1 lists estimates in the literature on the VMT elasticity with respect to the cost per mile of driving and Table II-2 lists estimates of the VMT elasticity with respect to the price of gasoline. The studies exhibit a wide variety of methodologies and use data

Table II-1. Estimates of the elasticity of VMT with respect to the cost per mile of driving.

Study	Data type	Source	Time frame	Short-run	Long-run
Mannering and Winston (1985)	RCS, HH	EIA	1977-1979	-0.23	-0.28
Mayo and Mathis (1988)	Nat TS	FHWA	1958-1984	-0.22	-0.26
Greene (1992)	Nat TS	FHWA	1957-1989	-0.05 to -0.19	-
Greene (1992)	Nat TS	FHWA	1966-1989	-0.09	-
Jones (1993)	Nat TS	FHWA	1966-1990	-0.11 to -0.13	-0.3
Schimek (1996)	Nat TS	FHWA	1950-1994	-0.05 to -0.17	-0.13 to -0.42
Goldberg (1998)	RCS, HH	CEX	1984-1990	0.0 to -0.2	-
Greene, Kahn, and Gibson (1999)	RCS, HH	RTECS	1979-1994	-	-0.23
Greening, Greene, and Difiglio (2000)	Meta-analysis		1990-2000	-0.1	-0.2 to -0.3
West (2004)	Cross-section	CEX	1997	-	-0.87
Small and Van Dender (2007)	RCS, states	FHWA	1966-2001	-0.05	-0.22
Bento et al. (2009)	Cross-section	NHTS	2001	-	-0.74
Hymel, Small, and Van Dender (2010)	RCS, states	FHWA	1966-2004	-0.05	-0.24
Hymel, Small, and Van Dender (2010)	RCS, states	FHWA	1984-2004	-0.05	-0.16
Notes: RCS = repeated cross-section, HH = household, Nat TS = national time series, EIA = Energy Information Administration, FHWA = Federal Highway Administration, CEX = Consumer Expenditure Survey, NHTS = National Household Travel Survey.					

Source: Gillingham (2011)

Table II-2. Estimates of the elasticity of VMT with respect to the price of gasoline.

Study	Data type	Source	Time frame	Short-run	Long-run
Sweeney (1979)	Nat TS	FHWA	1957-1974	-	-0.12 to -0.23
Gately (1992)	Nat TS	FHWA	1966-1989	-0.11	-0.11
Haughton and Sarkar (1996)	Panel, states	FHWA	1970-1991	-0.09 to -0.16	-0.22
Agras and Chapman (1999)	Meta-analysis		1982-1995	-0.15	-0.32
Pickrell and Schimek (1999)	RCS, HH	NPTS	1969-1995	-	-0.04 to -0.34
Kayser (2000)	Panel, HH	PSID	1981	-0.23	-
De Jong and Gunn (2001)	Meta-analysis			-0.16	-0.26
Goodwin, Dargay, and Hanley (2004)	Meta-analysis			-0.1	-0.3
Austin (2008)	Meta-analysis			-0.10 to -0.16	-0.26 to -0.31
Lin and Prince (2009)	California TS	CA	1970-2007	-	-0.07
Greene (2011)	Nat TS	FHWA	1967-2007	-0.05	-0.3
Notes: Nat TS = national time series, RCS = repeated cross section, HH = household, California TS = California time series, FHWA = Federal Highway Administration, NPTS = National Personal Transportation Survey, PSID = panel study of income dynamics, CA = California Energy Commission and California Air Resources Board.					

Source: Gillingham (2011).

from different sources that cover different time periods. The data sources range from household-level repeated cross-sectional data to national time series data to state-level repeated cross-sectional data. There is no obvious pattern in the resulting elasticities based on the data type or source, although studies based on purely cross-sectional data tend to have much higher elasticity estimates than all other studies. Some authors have argued that this is because other factors may be leading to an over-estimate of the elasticity (Greene 2011). For example, gasoline prices may be higher in cities where people drive less already, so the estimated elasticities will account for both the response to gasoline prices and the spatial structure of the areas where the data are available. It is possible to control for this, but it is not often done.

In addition, some studies estimate short-run elasticities (i.e., less than a year's time for the response) and others estimate long-run elasticities (i.e., several years). The short-run elasticity estimates for the VMT elasticity with respect to the cost per mile of driving range from zero to -0.23. The long-run estimates range from -0.13 to -0.87. The ranges are similar for the VMT elasticity with respect to the price of gasoline. The primary difference is that there are no published studies using purely cross-sectional data to estimate the VMT elasticity with respect to the price of gasoline, so the upper bound of the range of long-run estimates is just over -0.3, rather than -0.87.

These estimated elasticities are often multiplied by -100 and stated as a "percentage rebound effect," which, on the margin, is the percentage increase in VMT for a 1 percent decrease in the cost per mile of driving. For example, the range of the short-run direct rebound effect would be described as a 0% to 23% rebound effect instead of a VMT elasticity of 0 to -0.23.

The estimated elasticities in Table II-1 and Table II-2 are all VMT elasticities. Occasionally, some studies have referred to estimates of the price elasticity of gasoline demand elasticity as the (direct) rebound effect. The price elasticity of gasoline demand (i.e., the percentage change in the quantity demanded of gasoline over the price of gasoline) is not quite the correct metric to use, for it includes all consumer responses to changes in the price of gasoline: changes in driving, changes in new vehicle fuel economy, and any changes in the choice of whether or not to scrap an older vehicle. Thus, estimates of the price elasticity of gasoline demand would tend to be larger than estimates of the VMT elasticity with respect to the price of gasoline. The rebound effect of new vehicle performance standards has different effects on new vehicle fuel economy and the choice of whether or not to scrap an older vehicle, and thus the price elasticity of gasoline demand is a less appropriate metric to use for the rebound effect.

There are several additional clarifying points to make about the interpretation of these VMT elasticity estimates as the direct rebound effect. First, the elasticity estimates are best interpreted as the relationship between the cost of driving on the amount of driving at the values of driving, gasoline price, and fuel economy that we were exhibited during the time period of the studies. These estimated elasticities still provide useful guidance, but they should be interpreted in the context of the time frame and scope of the study. This is particularly important as the elasticities may change depending on both the time frame and scope of the study. Small and Van Dender (2007) and Hymel, Small, and Van Dender (2010) find that there is evidence suggesting a declining rebound effect over time, as consumers become wealthier and spend more time in traffic. The intuition for this result is that as consumers become wealthier and face more congested roads, the fuel cost of driving becomes relatively less important than the time cost of driving. Similarly, the average income in California is higher than in the rest of the United States – and roads in California are some of the most congested – so this result suggests that the rebound effect in California may be less than the rebound effect for United States-level studies.

Another important clarifying point is whether consumers would respond to a change in the cost per mile of driving due to new vehicle performance standards in the same way that they respond to changes in the cost per mile of driving due to a change in the price of gasoline. Greene (2011) uses aggregate national-level time series data to model the demand for gasoline as a function of both the price of gasoline and the average fleet fuel economy, and finds an insignificant coefficient on average fleet fuel economy. Greene interprets this result as perhaps suggestive of less responsiveness to changes in fuel economy than to changes in the price of gasoline. Gillingham (2011) uses California vehicle-level data to model the demand for driving in California as a function of the price of gasoline and the fuel economy of the vehicle.[1] Gillingham also finds evidence suggesting that the responsiveness to changes in fuel economy is less than the responsiveness to changes in the price of gasoline. Gillingham hypothesizes that such an asymmetry in responsiveness may be the result of gasoline price changes being more salient and noticeable to consumers than changes in fuel economy. Changes in gasoline prices are reported in the news and consumers see them on the signs at gasoline stations in addition to seeing their consequence on the gasoline bill. Changes in fuel economy would only affect the gasoline bill and could vary depending on travel patterns, driving style, topography, and accessory loads; thus, these changes may be somewhat less noticeable. Gillingham also notes that large changes in the cost per mile of driving (e.g., from large gasoline price swings) may lead to more responsiveness than small changes (e.g., from changes in fuel economy or small gasoline price swings). This is particularly true for large increases in prices. This

[1] Note that although the Gillingham study has not yet been published in a peer-reviewed journal, it is the most recent California-specific estimate of the rebound effect and provides a relevant data point. Additionally, ARB submitted the work for independent academic review and the three reviewers found the results and conclusions to be valid and reasonable (see Kahn, 2011; Noland, 2011; and Roach, 2011).

suggestive evidence indicates that the actual direct rebound effect from a new vehicle performance standard would be less than would be implied by estimates of the elasticity of driving with respect to the cost of driving that are estimated using variation from gasoline price changes.

A final clarifying point is that all of the studies in the literature focus on vehicles that use gasoline as the fuel. New vehicle regulations may induce consumers to purchase new vehicle technologies that use a different fuel. For example, some fraction of the new vehicle fleet may be electric vehicles by 2020. If some consumers switch from a gasoline vehicle to an electric vehicle, the cost per mile of driving for those consumers would be expected to decrease, perhaps quite substantially. This may induce these consumers to drive more – another manifestation of the rebound effect.

If consumers are rational and the transportation services provided by electric vehicles are the same as those provided by gasoline vehicles, then economic theory suggests that the rebound effect from switching to electric vehicles would be identical to the rebound effect estimated for gasoline vehicles. However, electric vehicles have a limited range before refueling and refueling is time-consuming. This may limit the usefulness of electric vehicles for entire classes of trips, such as any long-distance travel. If this limitation of electric vehicles is not resolved, then consumers may use electric vehicles differently than gasoline vehicles, and thus the transportation services from electric vehicles would differ from those from gasoline vehicles. Since electric vehicles will effectively have a constraint limiting the amount they can be driven, we might expect that the rebound effect due to switching from gasoline vehicles to electric vehicles would be less than the rebound effect we find for gasoline vehicles alone. In the absence of definitive evidence related to fuel switching , staff assumes changes to alternative fuel vehicles to be equivalent to gasoline vehicles.

A2. Value of the Rebound Effect Used for Analysis

Given the wide ranges of estimates and the important clarifying points, it is difficult to choose one single value of the rebound effect. In previous GHG rulemakings for light-duty vehicles, CARB used projections of the rebound effect over time based on the work of Ken Small and Kurt Van Dender (CARB, 2004). This work was subsequently published in 2007 as an article in the Energy Journal. For the current analysis, staff has considered all of the relevant literature and determined that the updated estimates from the work of Ken Small and Kurt Van Dender (published in Hymel, Small, and Van Dender (2010)) are appropriate to use. These updated estimates are the only ones in the published literature that allow extrapolation for a California-specific rebound effect into the future as income and congestion increases. Such an extrapolated California-specific rebound effect is particularly useful for the analysis of new vehicle fuel economy standards policy covering model years 2017 to 2025. In addition, the results from this analysis correspond with the California-specific estimated elasticity of VMT with respect to fuel economy in Gillingham (2011).

Staff's projection of the rebound effect over time involves three primary steps. First, we assembled the data from California to match the dataset in Hymel, Small, and Van Dender (2010). Importantly, we then extend the time series in the dataset out to 2030. Finally, we used the estimated coefficients from the model in Hymel, Small, and Van Dender (2010) to calculate the elasticity of VMT with respect to the cost per mile of driving for each year after the implementation of the new vehicle performance standards.

The calculations are based on four time series of data assembled by staff: income per capita, hours of congestion delay per adult, the price of fuel, and the fuel economy. The historical income per capita data are from the personal income data from the Bureau of Economic Analysis. The forecasted future income per capita data are from the UCLA Economic Forecast. The hours of congestion delay per adult are from the Texas Transportation Institute (TTI) and the US Census Bureau. In the forecasted data, the MSA-level population numbers compiled by TTI from the US Census Bureau are adjusted to match the US Census Bureau adult population numbers used in Hymel, Small, and Van Dender (2010). Historical gasoline price data are from the US Energy Information Administration. Data on the forecasted price of gasoline in California are the same as used throughout the economic analysis. The historical data on on-road new vehicle fuel economy are based on the sales-weighted average fuel economy from the CAFE standard, following Hymel, Small, and Van Dender (2010). The forecasted on-road fuel economy is based on the conversion of tailpipe CO_2 emissions from gasoline vehicles prior to crediting for air conditioning improvements; the baseline and policy scenarios each have different forecasted on-road fuel economy which results in scenario-specific rebound effects.

Based on these time series and the national-level averages of each of these variables (provided by Prof. Kenneth Small), we calculate the natural logarithm of these variables and then normalize these natural logarithms by the national-level averages. These transformed variables are the variables used in the analysis in Hymel, Small, and Van Dender (2010). Based on their estimated model the elasticity of VMT with respect to the price per mile of driving ($\varepsilon_{VMT,pm}$) is given by:

$$\epsilon_{VMT,pm} = \frac{dVMT}{dpm} = -0.0474 - 2(0.0251)pm + 0.0635Income - 0.0124Congestion,$$

where VMT is the normalized natural logarithm of VMT, pm is the normalized natural logarithm of the price per mile, $Income$ is the normalized natural logarithm of personal income per capita, and $Congestion$ is the normalized logarithm of the annual hours of congestion delay per adult. Each of the variables is normalized by subtracting the US average of the variables from the California estimate in each year.

Table II-3 shows the resulting estimates of the elasticity of VMT with respect to the cost per mile of driving over time for the baseline and Advanced Clean Cars program scenarios.[2] The Hymel, Small, and Van Dender (2010) model suggests that regardless of the scenario, the short-run elasticity of VMT with respect to the cost per mile of driving begins around -0.06 and by 2030 reaches -0.03. For both scenarios, taking these estimates as the rebound effect from new vehicle performance standards implies a 6% rebound effect in 2012, a 5% rebound effect in 2020, and a 3% rebound effect by 2030. This suggests a declining rebound effect as Californians become wealthier over time. The addition of the proposed Advanced Clean Cars program slows this decline slightly, however once the standards are fully phased-in the rebound effect is essentially the same as it would have been absent the program.

Table II-3. Estimated future elasticities of VMT with respect to the cost per mile of driving in California

Calendar Year	Baseline Scenario	Advanced Clean Cars Scenario
2012	-0.06	-0.06
2013	-0.06	-0.06
2014	-0.06	-0.06
2015	-0.06	-0.06
2016	-0.05	-0.06
2017	-0.05	-0.05
2018	-0.05	-0.05
2019	-0.05	-0.05
2020	-0.05	-0.05
2021	-0.04	-0.05
2022	-0.04	-0.04
2023	-0.04	-0.04
2024	-0.03	-0.04
2025	-0.03	-0.04
2026	-0.03	-0.03
2027	-0.03	-0.03
2028	-0.03	-0.03
2029	-0.03	-0.03
2030	-0.03	-0.03

As context, a rebound effect in the range of 6% was also estimated by Gillingham (2011) using data for the years 2001 to 2009 in response to a hypothetical feebate

[2] The baseline is adjusted to account for changes in operating costs related to existing standards applied to pre-MY2017 vehicles.

policy. While this estimate may more closely reflect the actual response in VMT to a new vehicle performance standard policy, Gillingham's model is not suitable for extrapolation to future years. Thus, CARB is relying upon the estimates of Hymel, Small, and Van Dender (2010) for the rebound effect in future years.

In contrast, US EPA and NHTSA in previous related rulemakings have assumed a constant rebound effect of 10% (or an elasticity of -0.1) based on a review of the literature, but not relying on a single model or estimate. While this may be an appropriate assumption for a national analysis, staff believes that higher congestion and income levels in California relative to national averages justifies the use of a lower value for the rebound effect. However, staff evaluates a 10 percent sensitivity case as part of the emissions analysis.

A3. Application of the Rebound Effect to Adjust Vehicle Miles Traveled

The projected rebound effects based on the methods described above are then used to adjust vehicle miles traveled (VMT) for the emissions analyses. As discussed previously, the rebound effect relates the percent change in VMT relative to the percent change in operating costs from the proposed program. Table II-3 showed that the rebound effect varies by calendar year due to changes in the input variables, e.g. income levels and congestion, as well as by scenario. Operating costs will also vary by scenario as well as by vehicle model year and vehicle category (e.g. passenger car or light truck).

Future VMT estimates in EMFAC provided by the regional planning organizations already incorporate expected changes in travel demand due to factors such as income, fuel prices, the distance between one's home and job, desired discretionary driving, transit options, and many other driving related costs. Note that future fuel prices are assumed to be unaffected by the proposed program. Thus, adjustments to future VMT resulting from the rebound effect are based only on the changes in operating costs due to vehicle technology. As staff only projected the rebound effect up to 2030, the rebound effect in years beyond was assumed to remain the same as CY2030 (i.e. staff did not assume a continuing decline).

Because the National Program for MY2012-2016 light-duty vehicles was not in place when VMT forecasts were originally made, VMT estimates for the Baseline scenario are first adjusted to reflect the reduced operating costs that will result from this regulation. Percentage reductions in operating costs are all relative to MY2009 vehicles and based on gasoline technology. These percentages are then multiplied by the projected rebound effect for each future calendar year shown in Table II-3 to generate a matrix of percentage increases in VMT. The percent change in VMT ranged from 0.3 percent to 1 percent depending on the vehicle category, model year, and calendar year, with the smaller changes applying to earlier years while the standard is phasing-in. For CY and

MYs 2017-2025, VMT of passenger cars and light trucks was increased by about 1 percent uniformly. The same VMT adjustments were applied to all vehicle technology types; as discussed previously, responses to alternative fuel vehicles are currently uncertain.

Similar percentage changes were calculated for the Advanced Clean Cars policy scenario, where changes in operating costs are likewise relative to MY2009 vehicles and based on gasoline technology and using the ACC projected rebound effects. Examples of the resultant increases in VMT are shown in Table II-4 and Table II-5. Appendix T provides additional details on how VMT adjustments are applied to the emissions inventories.

Table II-4. Percent Increase in VMT for Passenger Cars due to Rebound Effect of Advanced Clean Cars

	CY2017	CY2018	CY2019	CY2020	CY2021	CY2022	CY2023	CY2024	CY2025
Rebound:	5%	5%	5%	5%	5%	4%	4%	4%	4%
MY2017	1.1%	1.1%	1.1%	1.1%	1.1%	0.9%	0.9%	0.9%	0.9%
MY2018		1.2%	1.2%	1.2%	1.2%	0.9%	0.9%	0.9%	0.9%
MY2019			1.3%	1.3%	1.3%	1.0%	1.0%	1.0%	1.0%
MY2020				1.3%	1.3%	1.1%	1.1%	1.1%	1.1%
MY2021					1.4%	1.1%	1.1%	1.1%	1.1%
MY2022						1.2%	1.2%	1.2%	1.2%
MY2023							1.3%	1.3%	1.3%
MY2024								1.3%	1.3%
MY2025									1.4%

Table II-5. Percent Increase in VMT for Light Trucks due to Rebound Effect of Advanced Clean Cars

	CY2017	CY2018	CY2019	CY2020	CY2021	CY2022	CY2023	CY2024	CY2025
Rebound:	5%	5%	5%	5%	5%	4%	4%	4%	4%
MY2017	1.1%	1.1%	1.1%	1.1%	1.1%	0.9%	0.9%	0.9%	0.9%
MY2018		1.2%	1.2%	1.2%	1.2%	0.9%	0.9%	0.9%	0.9%
MY2019			1.3%	1.3%	1.3%	1.0%	1.0%	1.0%	1.0%
MY2020				1.3%	1.3%	1.1%	1.1%	1.1%	1.1%
MY2021					1.5%	1.2%	1.2%	1.2%	1.2%
MY2022						1.2%	1.2%	1.2%	1.2%
MY2023							1.3%	1.3%	1.3%
MY2024								1.4%	1.4%
MY2025									1.5%

III. Environmental-Dynamic Revenue Analysis Model (E-DRAM)

The major tool used for the analysis of the economic impact of the proposed regulation is a model of the California economy developed by the University of California, Berkeley, named the Environmental Dynamic Revenue Analysis Model (E-DRAM). Specifically, E-DRAM was used to estimate impacts on California's output of goods and services, personal income, and employment. The estimates of the regulation's impact on these economic factors are used to assess the potential impacts on business creation, elimination, or expansion in California.

A. Model Description

E-DRAM is a computable general equilibrium (CGE) model of the California economy that estimates the overall impact of direct and indirect economic effects that may result from the proposed regulation. A direct impact affects the automobile and oil industries, and their consumers. The proposed regulation may affect other economic sectors indirectly. For example, consumers are likely to redirect money from operating cost savings to spend in other sectors. In addition, the automobile industry would be expected to purchase goods and services from other sectors to comply with the proposed regulation. These expenditures caused by the regulation would indirectly affect the California economy.

A CGE model simulates various economic relationships in a market economy, where prices and production adjust in response to changes caused by regulations to establish an equilibrium in markets for all goods and services and factors of production (i.e., labor and capital). E-DRAM is a modification of the CGE model, Dynamic Revenue Analysis Model (DRAM), which has been used by the California Department of Finance for several tax policy evaluations. The modified model accounts for environmental sectors and has been used to assess the economic impacts of California’s air quality State Implementation Plans, the AB32 Scoping Plan, reformulated gasoline regulations, vehicle greenhouse gas standards, and other regulations.

E-DRAM describes the relationships among California producers, California consumers, government, and the rest of the world. The model consists of over 1,000 equations designed to capture the interactions among 86 industrial sectors, 2 factors of production sectors (labor and capital), 8 consumer good sectors, 6 household sectors (classified by income level), 1 investment sector, 45 government sectors (8 federal, 21 State, and 8 local), and the rest of the world.

The data for the industrial sectors originated with the Bureau of Economic Analysis of the U.S. Department of Commerce benchmark input output data for 2002. The conversion of national data to more recent 2006 California data is accomplished using wage ratios based on the Bureau of Labor Statistics’ Quarterly Census of Employment and Wages. In much the same way as firms, households are also aggregated.

California households are divided into categories based upon their taxable income. There are seven such categories in the model, each one corresponding to a California personal income tax marginal tax rate (1, 2, 4, 6, 9.3 percent, and 9.3 percent for incomes greater than $200k). Thus, the income for the "one-percent" household is calculated by adding up the income from all households in the one-percent bracket. Similarly, the expenditure of the one-percent household on agricultural goods is calculated by adding up all expenditures on agricultural goods for these households. The total expenditure on agricultural goods is found by adding the expenditure of all households together.

Firms and households relate through factor markets and goods-and-services markets. Firms sell goods and services to households on the goods-and-services markets. Households sell labor and capital services to firms on the factor markets. There is a price in each of the factor and goods-and-services markets. Equilibrium in the factor markets and the goods-and-services markets means that prices adjust in response to changes caused by regulations to equate quantities supplied and demanded in all markets in about four years. That is, the full effects of a change take four years to work their way through the economy.

The impacts of regulations are estimated by changing the inputs to the model that represent regulation effects on the industry or consumer sectors. Such changes to the model enable it to assess the economic impacts of large-scale environmental regulations. The economic impact results are estimated in terms of changes in the State output of goods and services, personal income, and employment. See Appendix G-II of the Proposed Scoping Plan for further background about E-DRAM and Prof. Berck's website[3] or the ACC 1085 website to download model files.

B. Extrapolating Baseline Conditions

The E-DRAM model is built to reproduce the economic conditions of fiscal year 2005-2006. Thus, a baseline scenario is first generated by extrapolating certain parameters into the future based on UCLA's Anderson Forecast (June 2011) for State population and personal income. Total statewide motor vehicle fuel consumption is also normalized relative to 2006 levels to reflect implementation of the National Program for MY2012-2016 where future fuel consumption is based on baseline emissions assumptions and average historic vehicle data are taken from US EPA's "Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010."

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[3] http://afs.berkeley.edu/~pberck/Research/EDRAM06/index.htm (Accessed September 23, 2011)

C. Generating Scenario Inputs

Each future year represents a separate scenario where the statewide economy is shocked on an aggregate basis. ARB staff generated scenarios for the years 2020, 2025, and 2030 for the proposed Advanced Clean Cars program and the LEV III amendments only. A positive shock is imposed from the consumer transportation sector to the vehicle manufacturing sector to account for the incremental vehicle prices resulting from the policy. The value of the transaction is based on the total annualized compliance costs. These costs are derived by multiplying new vehicle sales by the average per vehicle price increase described above. The new vehicle sales totals are based on the projected compliance scenario fitted to new vehicle registrations estimates forecast by EMFAC2011. The total costs to consumers vary each year from 2015 to 2030 which are annualized for each model year over the life of the vehicle using a discount rate of 5 percent. The median life of a passenger car is assumed to be 14 years, a light truck 17 years, and medium-duty vehicle 20 years based on survival probabilities in EMFAC2011. The annualized costs are then summed across the model years existing within a calendar year. For example, the annualized cost in 2020 reflects the annualized costs of model years 2015 through 2020. Thus, the annualized costs for each calendar year are for cumulative sales of new vehicles since 2015. The positive shocks for the various scenarios are shown in Table III-1. An additional sensitivity case was generated by annualizing compliance costs over 5 years to correspond with average new vehicle loan periods; for 2030, costs increase slightly to $3.43 billion.

Table III-1. Total Annualized Compliance Costs (billions of 2009 dollars)

Year	ACC	LEVIII Only
2020	$0.39	$0.32
2025	$1.83	$1.34
2030	$3.43	$2.50

Other positive shocks are also expected to occur, mostly in the ACC scenario, due to increased consumption of electricity and hydrogen for ZEVs. The full value of electricity expenditures is transferred from the consumer fuels sector to the electricity generation and distribution sector. For hydrogen, the transfer is expected to come from the oil refinery and fuel provider sector as a result of the Clean Fuels Outlet amendments. Due to the various pathways for hydrogen production, the value of hydrogen expenditures is distributed across the electricity sector, basic chemicals industry, and the natural gas distribution sector. As the magnitude of hydrogen expenditures is small relative to the size of the total California economy, the results are insensitive to the distribution across the sectors. The value of electricity and hydrogen expenditures are shown in Table III-2.

Table III-2. Estimated Increases in Electricity and Hydrogen Expenditures (billions of 2009 dollars)

	ACC		LEVIII Only	
Year	Electricity	Hydrogen	Electricity	Hydrogen
2020	$0.06	$0.02	$0.01	$0.02
2025	$0.35	$0.17	$0.05	$0.06
2030	$0.62	$0.37	$0.08	$0.10

Two negative transaction shocks are imposed as a result of the policies. First, 82 percent of the expected reduction in consumer motor fuel expenditures are taken away from the oil refinery sector due to the reductions in fuel consumption and the remainder of the expenditures are taken away from the retail gasoline sector for reductions in services. The ratio between these two sectors is based on the SAM2006. The fuel prices in Table III-3 are used to estimate the total reductions in consumer motor fuel expenditures are shown in Table III-4.

Table III-3. Retail Gasoline Fuel Prices (2009 dollars per gallon)

Year	Price
2020	$4.06
2025	$4.02
2030	$4.17

Table III-4. Estimated Reductions in Consumer Motor Fuel Expenditures (2009 dollars)

Year	ACC	LEVIII Only
2020	$1.52 billion	$1.40 billion
2025	$6.28 billion	$6.29 billion
2030	$11.62 billion	$11.35 billion

D. Scenario Results

Table III-5 summarizes the impacts of the proposed Advanced Clean Cars program on the California economy for forecast years 2020, 2025, and 2030. The results of the E-DRAM simulation show that the changes caused by the proposed regulations would increase the California economic output by roughly $2 billion (0.1 percent) in 2020, $8 billion (0.2 percent) in 2025, and $14 billion (0.3 percent) in 2030. Personal income would increase more gradually, remaining almost unchanged in 2020 but increasing by roughly $3 billion (0.1 percent) in 2025, and $6 billion (0.2 percent) in 2030. As a result, California net employment impacts due to the proposed regulation would also remain about constant in 2020, but increase slightly by 21,000 jobs (0.1 percent) in 2025, and 37,000 jobs (0.2 percent) in 2030.

Two sensitivity case were run for the forecast year 2030 with the ACC program to evaluate the effects of different assumptions on compliance costs and fuel prices. Annualizing compliance costs over the life of the loan instead of the life of the vehicle results in greater vehicle expenditures in the later years. Percentage-wise, the effects on the California economy are identical, as shown in Table III-6. The second sensitivity assumes that gasoline prices are 30 percent higher than the CEC average, which translates into reductions in motor fuel expenditures on the order of $15.1 billion (2009 dollars). Changing this assumption yields greater positive impacts on the state, though the impacts are still rather small relative to the size of the economy.

In the event that only the LEV III amendments are adopted, the impacts to the California economy would be similar, if not slightly more positive. Thus, the ACC scenarios remain the more conservative cases. The results of the E-DRAM simulation shown in Table III-7 indicate that the changes caused by the proposed amendments would also increase the California economic output by roughly $2 billion (0.1 percent) in 2020, $11 billion (0.3 percent) in 2025, and $19 billion (0.4 percent) in 2030. Personal income would increase more gradually, remaining almost unchanged in 2020 but increasing by roughly $3 billion (0.1 percent) in 2025, and $7 billion (0.2 percent) in 2030. As a result, California net employment impacts due to the proposed regulation would also remain about constant in 2020, but increase slightly by 26,000 jobs (0.1 percent) in 2025, and 44,000 jobs (0.2 percent) in 2030.

Table III-5. Economic Impacts of the Proposed Advanced Clean Cars (ACC) Program on the California Economy in 2020, 2025, 2030 (2009 dollars)

	Baseline	With ACC Program	Difference	% of Total
2020				
Output (Billions)	$3,600	$3,602	$2	0.1
Personal Income (Billions)	$2,171	$2,172	$1	0.0
Employment (thousands)	17,913	17,919	6	0.0
2025				
Output (Billions)	$4,170	$4,178	$8	0.2
Personal Income (Billions)	$2,525	$2,528	$3	0.1
Employment (thousands)	18,966	18,987	21	0.1
2030				
Output (Billions)	$4,881	$4,895	$14	0.3
Personal Income (Billions)	$2,962	$2,968	$6	0.2
Employment (thousands)	20,179	20,216	37	0.2

Note: Difference of individual columns may not match due to rounding.

Table III-6. Sensitivity Analysis of Proposed Advanced Clean Cars (ACC) Program on the California Economy in 2030 (2009 dollars)

	Baseline	With ACC Program	Difference	% of Total
Main Case				
Output (Billions)	$4,881	$4,895	$14	0.3
Personal Income (Billions)	$2,962	$2,968	$6	0.2
Employment (thousands)	20,179	20,216	37	0.2
Alternate Compliance Costs				
Output (Billions)	$4,881	$4,894	$13	0.3
Personal Income (Billions)	$2,962	$2,968	$6	0.2
Employment (thousands)	20,179	20,215	36	0.2
30% Higher Fuel Price				
Output (Billions)	$4,913	$4,930	$18	0.4
Personal Income (Billions)	$2,962	$2,970	$8	0.3
Employment (thousands)	20,179	20,233	54	0.3

Note: Difference of individual columns may not match due to rounding.

Table III-7. Economic Impacts of the Proposed LEV III Amendments on the California Economy in 2020, 2025, 2030 (2009 dollars)

	Baseline	With LEV III Only	Difference	% of Total
2020				
Output (Billions)	$3,600	$3,602	$2	0.1
Personal Income (Billions)	$2,171	$2,172	$1	0.0
Employment (thousands)	17,913	17,919	6	0.0
2025				
Output (Billions)	$4,170	$4,180	$11	0.3
Personal Income (Billions)	$2,525	$2,528	$3	0.1
Employment (thousands)	18,966	18,992	26	0.1
2030				
Output (Billions)	$4,881	$4,900	$19	0.4
Personal Income (Billions)	$2,962	$2,969	$7	0.2
Employment (thousands)	20,179	20,223	44	0.2

Note: Difference of individual columns may not match due to rounding.

In all cases, consumers would spend more on the purchase of motor vehicles, thus having less money to spend on the purchase of other goods and services. Since most automobile manufacturing occurs outside of the State, the increased consumer expenditures on motor vehicles would reduce economic activity within California. However, the reduction in operating costs resulting from improved vehicle technology would reduce consumer expenditures and would therefore leave California consumers with more disposable income to spend on other goods and services. The greater the savings, the greater the economic benefits. Businesses that serve local markets are most likely to benefit from the increase in consumer expenditures. The increase would in turn boost the California economy slightly, resulting in the creation of some additional jobs.

The output from E-DRAM is based on the assumption that the future structure of California's economy remains similar to current existing conditions. These results are thus only illustrative of the potential macroeconomic effects that might occur with the implementation of the proposed amendments as opposed to a forecast of future economic growth. The relatively small percentage change in this context means that the uncertainty of future economic structures may offset some of these positive effects. However staff believes it is unlikely that the proposed amendments *per se* would result in significant negative economic impacts. In fact, the technology-forcing nature of the program could stimulate growth in certain sectors, which would not be reflected in the model's existing linkages between sectors. For instance, electric vehicle manufacturers and clean energy companies that have recently been established in the state would have the potential of expanding their businesses and exporting their products to other parts of the country or the world.

IV. Social Cost of Carbon

The social cost of carbon (SCC) is a monetary estimate of future damages resulting from the emission of one additional metric ton of carbon dioxide in a specific year. The scope of climate change impacts included in SCC varies by estimate: it may be local or global, cover one or many sectors of the economy, and include or exclude impacts such as ecosystems services or biological diversity. SCC values discussed in this section apply only to carbon dioxide emissions. Values for other greenhouse gases (GHGs) are under development.

The scale or scope of climate change impacts cannot be predicted with precision or certainty. But the California legislature, the U.S. Environmental Protection Agency, the U.S. Supreme Court and the global scientific community have determined that increasing GHG emissions threaten human health and welfare for current and future generations.[4]

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[4] California Global Warming Solutions Act of 2006; Environmental Protection Agency Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act; Final Rule, Federal Register, 12/15/2009; U.S. Supreme Court, Massachusetts v. Environmental Protection Agency, 549 U.S. 497 (2007); Synthesis Report, Fourth Assessment Report of the Intergovernmental

Given the consensus that climate change caused by anthropogenic emissions of carbon dioxide, (CO_2), and other GHGs will result in widespread, long-term environmental and economic damage, it would be inconsistent to assign a zero value to the reduction of climate change emissions. Regulations that reduce future CO_2 emissions benefit the environment and the economy by preventing damages. However, our understanding of the environmental and economic impacts of climate change is incomplete, and the methods used to quantify and monetize those impacts are unsettled.

Recognizing the need to assign value to the social costs of GHG emissions, ARB staff monetizes the social benefits of the proposed rule's reduction of CO_2 emissions using SCC values published by the U.S. government. (See Table IV-1). Due to the provisional and uncertain nature of these estimates however, ARB staff excludes SCC-derived benefits from its primary economic impact analysis and cost-effectiveness estimates.

A. Federal SCC Values

Federal agencies have developed and applied a range of global SCC values in regulatory impact analyses (RIAs) since 2008. Most recently, the U.S. government's Interagency Working Group on the Social Cost of Carbon[5] estimated SCC values to enable agencies to incorporate the social benefits of reducing carbon dioxide into benefit-cost analyses of regulations with small impacts on cumulative global emissions. The interagency group's values have been applied in 2010 RIAs completed by USEPA, USDOE and USDOT-NHTSA.[6]

The U.S. government is committed to periodically reviewing and updating SCC values. Its current SCC values result from averaging the outputs of three peer-reviewed integrated assessment models (IAMs).[7] The models translate emission changes into atmospheric GHG concentrations, atmospheric GHG concentrations into temperature changes and temperature changes into global economic damages.

Panel on Climate Change; Core Writing Team, Pachauri, R.K. and Reisinger, A. (Eds.) 2007 IPCC, Geneva, Switzerland.

[5] Agencies participating in the Working Group include: Council of Economic Advisors; Council on Environmental Quality; Department of Agriculture; Department of Commerce; Department of Energy; Department of Transportation; Environmental Protection Agency; National Economic Council; Office of Energy and Climate Change; Office of Management and Budget; Office of Science and Technology Policy; Department of the Treasury.

[6] USEPA Renewable Fuel Standard Program (RFS2) RIA, (EPA-420-R-10-006) February 2010; USDOE Energy Conservation Program: Energy Conservation Standards for Small Electric Motors; Final Rule March 9, 2010; USEPA-NHTSA Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Standards and Corporate Average Fuel Economy, Regulatory Impact Analysis, April 2010.

[7] "Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866," February 2010, EPA-HQ-OAR-2009-0472 See pages 5-11 for discussion of the three integrated assessment models. Accessed 11/17/11 at: http://www.epa.gov/otaq/climate/regulations/scc-tsd.pdf

The interagency group selected four different values for the social cost of CO_2 emissions in any given year: three values based on the average SCC across models and socio-economic and emissions scenarios, discounted at 2.5%, 3% and 5% rates; and a fourth value – the 95th percentile of model estimates -- to represent higher-than-expected or catastrophic damages. (See Table IV-1, below.) Taking one example from the table, $33 represents the stream of future damages caused by the emission of one additional metric ton of CO_2 in the year 2030, when those post-2030 damages are discounted at 3%. To estimate the social benefits of an entire regulatory program, SCC values ($) for all impacted years are multiplied by annual CO_2 emission reductions (MT CO_2), converted to a net present value using the same discount rate, (3%), and summed.

Table IV-1. SCC Values: Federal Interagency Working Group

Global Social Cost of CO_2 Emitted in 2020, 2025, 2030 & 2040 (2009$/Metric Ton)[8]				
Discount Rate	5%	3% "Central Value"	2.5%	3%
Emissions Year	Avg., 3 models	Avg., 3 models	Avg., 3 models	95th percentile
2020	$7	$27	$43	$84
2025	$8	$31	$47	$94
2030	$10	$34	$52	$103
2040	$13	$41	$60	$123

Source: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866,

U.S. Interagency Working Group on Social Cost of Carbon, 2010

Future damages from climate change are discounted to reflect society's marginal rate of substitution between consumption in the present and in the future. The working group emphasizes the use of a range of SCC values to reflect the uncertainties of estimating the future benefits of reducing CO_2 emissions, but identifies the value discounted at 3% as its "central value." Discount rates of 3% and 7% are often used for social discounting in the context of Federal regulatory programs, however, the Office of

[8] Table values differ marginally from those in the U.S. EPA Preamble (76 Fed.Reg. No. 231, December 1, 2001, Table III-70, p. 75128) because U.S. EPA uses a GDP price index rather than a consumer price index to adjust for inflation.

Management and Budget's Circular A-4 suggests using a lower, but still positive discount rate when considering inter-generational costs.[9]

Despite the use of discounting to calculate the net present value of future benefits, the interagency group's annual unit SCC values increase over time. Future emissions are expected to become more damaging as physical and economic systems become more stressed in response to increased climatic change.

The interagency working group acknowledges that its published SCC values are uncertain, provisional, and revisable. The group also identifies limitations that may cause its analysis to underestimate SCC by omitting adverse consequences, including:

- Non-catastrophic damages such as ocean acidification, and species and wildlife loss;
- Potential catastrophic damages resulting from discontinuous "tipping point" behavior in earth systems;
- Inter-sectoral and inter-regional interactions, including global security impacts of high-end warming; and,
- Limited near-term substitutability between damage to natural systems and increased consumption.

In addition, Federal SCC values do not apply to non-CO_2 greenhouse gas emissions, as noted above. According to the working group,[10] translating emissions of other GHGs into CO_2 equivalents (GWP) and then applying CO_2 SCC values does not yield accurate estimates of the social costs of non-CO_2 gases.

B. Geographic Scope of SCC Values

Economic impact analyses of ARB regulations focus on the costs and benefits of regulatory programs for California businesses, agencies and individuals. Usually, analysis is limited to direct, in-state impacts. But unlike ARB's regulatory programs for criteria pollutants and air-toxics, the AB32 control program targets GHGs, which, while emitted locally, exert global impacts.

The California Global Warming Solutions Act of 2006 (AB32) takes a global view of GHG emission controls. AB32 requires ARB to consider impacts "outside the state" to minimize "leakage" of its GHG-reducing regulations, and directs the Board to, "consider all relevant information pertaining to greenhouse gas emission reduction programs in other states, localities and nations…"

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[9] Executive Office of the President, Office of Management and Budget, Circular A4, Regulatory Analysis, September 17, 2003. See Section E, Identifying and Measuring Benefits and Costs, Discount Rates, 4. Intergenerational Discounting. Accessed 11/17/11 at: http://www.whitehouse.gov/omb/circulars_a004_a-4/#e

[10] "Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866," February 2010, EPA-HQ-OAR-2009-0472 p.13

The costs or benefits of climate-changing emissions may be assessed globally, nationally or locally. The Federal interagency working group's SCC estimate and recent U.S. government RIAs focus primarily on global benefits. Estimates of domestic benefits are also considered, but Federal analysts emphasize the global benefits of GHG emission reductions in their regulatory benefit-cost calculations.

The U.S. interagency group focuses on the global benefits of CO_2 emission reductions because of the global aspects of those emissions:

- Local changes in CO_2 emissions influence the global climate. In a practical sense, local regulatory decisions result in global economic damages or benefits;
- The ultimate effectiveness of local efforts to slow climate change depends on global cooperation. Local jurisdictions optimize the benefits of their regulatory actions if they encourage a global regulatory response;
- Global climate change can trigger trans-border political or economic reactions which in turn have domestic or local impacts.

Assigning a value of zero to non-local benefits weakens the impetus for both local and non-local programs to reduce climate change. Like Federal agencies, ARB employs global SCC values to calculate the social benefits of proposed rules.

C. Social Benefits of ACC

The proposed rule will substantially reduce combustion, distribution, refining and extraction of gasoline for an extended period. The private economic benefits that accrue to vehicle owners as a result of the rule, (fuel savings, e.g.), are quantified and discussed in the primary economic impact analysis in Section VII of the ISOR.

Additional economic benefits – social benefits -- can be attributed to the global climate change impacts of reducing fuel production, distribution and combustion. To calculate the economic value of the social benefits of the proposed rule, ARB applies global SCC values published by the U.S. Interagency Working group. Because those values apply only to emissions of carbon dioxide, the benefits of reducing non-CO_2 GHG emissions are not included here.

Table IV-2 displays the range of projected SCC benefits estimated to result from the regulation as currently proposed. Amounts are expressed in billions of 2009$ and represent the net present value of climate change damages avoided as a result of CO_2 emission reductions in the specified year(s). For the "Central Value," which discounts future benefits at 3% annually, the proposed regulation would avoid $20 billion of climate change damages through 2040.

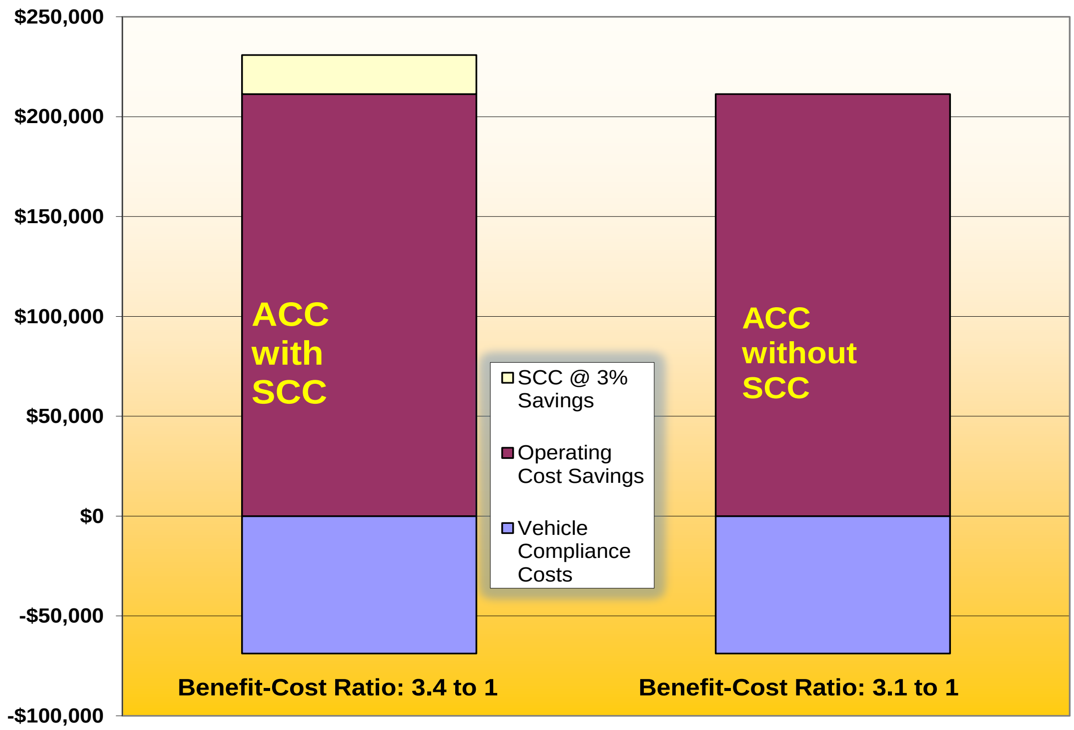
Table IV-2. Social Benefits of Projected ACC CO_2 Emission Reductions

Global Social Benefits of ACC CO2 Reductions, (Billions of 2009$) in Selected Years and Cumulated through 2040				
Discount Rate	5%	3%	2.5%	3%
Emissions Year		"Central Value"		
	Avg., 3 models	Avg., 3 models	Avg., 3 models	95th percentile
2020	$.03 Bn	$.10 Bn	$.16 Bn	$.30 Bn
2025	$.13 Bn	$.49 Bn	$.76 Bn	$1.5 Bn
2030	$.28 Bn	$.95 Bn	$1.5 Bn	$2.9 Bn
2040	$.56 Bn	$1.7Bn	$2.6 Bn	$5.2 Bn
2017-2040	$5.9 Bn	$20 Bn	$30 Bn	$59 Bn

Combining the estimated social benefits of projected CO_2 emission reduction with the private economic benefits discussed in Section VII-B improves the overall benefit-cost ratio of the proposed rule. However, the social benefits of CO_2 emission reduction were not considered in setting the stringency of the proposed ACC-GHG standards.

Figure IV-1, below, compares the overall benefit cost ratio of the proposed ACC standard with and without the social cost of carbon. Had SCC been integrated with the primary economic impact analysis for the proposed program, its inclusion would not have significantly impacted ACC's overall benefit-cost ratio. This is because the private value of fuel exceeds the estimated social cost of the externalities associated with its combustion.

Figure IV-1. Benefit-Cost Ratios of ACC through 2040 with and without Social Cost of Carbon (Millions of 2009$)



V. Consumer Savings Calculations

To provide a perspective on the potential impact of the proposed regulations on the typical purchasers of new and used vehicles, staff estimated various consumer savings metrics.

For new vehicles that are financed, the loan terms are assumed to be five year (61 month) maturity period at an interest rate of 5 percent, based on data from the Federal Reserve.[11] The incremental vehicle price of $1900 (2009 dollars) for a new MY2025 vehicle is based on the expected sales-weighted increase as a result of the complete and fully-phased in Advanced Clean Cars program. Assuming that the entire value of the incremental vehicle price is financed, monthly loan payments would increase correspondingly by $35. Increases in monthly payments on the incremental vehicle price are then compared to monthly operating cost savings.

[11] US Federal Reserve Historical Car Loan Data http://www.federalreserve.gov/releases/g20/hist/fc_hist_tc.txt (Accessed September 20, 2011)

All vehicle technologies (gasoline, PHEV, EV, and FCVs) are assumed to have the same VMT schedule based on EMFAC2011 accrual rates, where VMT varies only as a function of the vehicle age, vehicle category (PC vs. LT) and as a result of the rebound effect. Changes in VMT resulting from the rebound effect are calculated using the change in operating costs of exclusively gasoline-capable vehicles, i.e. conventional internal combustion or non-plug-in hybrid vehicles, and therefore will vary by model year. Overall, light-duty vehicles are estimated to travel on the order of 17,000 miles annually during their first five years. New passenger cars are assumed to have a median life of 14 years and new light trucks a median life of 17 years based on survival probabilities in EMFAC2011.

Table V-1. VMT Schedule for MY2025 Vehicles (including rebound)

MY2025	Baseline		Advanced Clean Cars	
Age	PC VMT	LT VMT	PC VMT	LT VMT
1	20,682	21,353	20,776	21,482
2	17,895	18,739	17,912	18,781
3	16,263	17,208	16,279	17,247
4	15,102	16,119	15,117	16,155
5	14,202	15,273	14,216	15,307
6	13,468	14,596	13,482	14,629
7	12,844	14,011	12,857	14,043
8	12,304	13,503	12,316	13,533
9	11,826	13,053	11,838	13,082
10	11,399	12,651	11,411	12,679
11	11,023	12,303	11,034	12,331
12	10,671	11,970	10,681	11,997
13	10,349	11,669	10,359	11,695
14	10,050	11,386	10,060	11,411
15	N/A	11,124	N/A	11,149
16	N/A	10,883	N/A	10,907
17	N/A	10,654	N/A	10,678

Based on the mileage rates (an example for MY2025 vehicles is shown in Table V-1), annual operating costs are calculated for each technology type according to their respective energy intensity levels and the energy prices shown in Table V-2, Table V-3, and Table V-4. Plug-in hybrids are assumed to have an all-electric range of 20 miles and therefore use electricity for 40 percent of their VMT according to the Society of Automotive Engineers J2841 standard. The technology-specific annual operating costs are then averaged based on their proportion within the fleet. The same survival rates are assumed for all technology types so that their initial sales shares will reflect the

Table V-2. Retail Gasoline Prices (2009 dollars per gallon)

Year	CEC Low Case	CEC Average	CEC High Case	30% Higher than CEC Average
2011	$3.21	$3.68	$4.16	$4.78
2012	$3.24	$3.82	$4.40	$4.97
2013	$3.28	$3.90	$4.53	$5.07
2014	$3.32	$3.99	$4.66	$5.19
2015	$3.35	$4.06	$4.76	$5.28
2016	$3.34	$4.06	$4.79	$5.28
2017	$3.32	$4.07	$4.81	$5.29
2018	$3.31	$4.07	$4.84	$5.29
2019	$3.29	$4.07	$4.84	$5.29
2020	$3.28	$4.06	$4.85	$5.28
2021	$3.24	$4.05	$4.86	$5.27
2022	$3.21	$4.04	$4.87	$5.25
2023	$3.17	$4.02	$4.87	$5.23
2024	$3.14	$4.02	$4.90	$5.23
2025	$3.10	$4.02	$4.94	$5.23
2026	$3.12	$4.04	$4.97	$5.25
2027	$3.13	$4.08	$5.02	$5.30
2028	$3.14	$4.11	$5.08	$5.34
2029	$3.15	$4.13	$5.11	$5.37
2030	$3.16	$4.17	$5.18	$5.42

Note: After 2030, gasoline prices are assumed to increase linearly at a rate of 0.7% annually.
Source: California Energy Commission (2011) Transportation Energy Forecasts and Analyses for the 2011 Integrated Energy Policy Report, Draft Staff Report. CEC-600-2011-007-SD.

Table V-3. Retail Price of Hydrogen (2009 dollars)

Year	Price/kg H_2
2017	$13.00
2018	$13.00
2019	$12.00
2020	$11.00
2021	$10.00
2022	$9.00
2023	$8.00
2024	$7.00
2025+	$6.00

Source: Amendments to the Clean Fuels Outlet Regulation, Initial Statement of Reasons, 2011.

Table V-4. Retail Price of Electricity for Transportation (2009 dollars)

Year	Price/kWh
All	$0.15

Source: Amendments to the California Zero Emission Vehicle Regulation, Initial Statement of Reasons, 2011.

future fleet mix as well. The difference between the annual operating costs in the baseline and policy scenarios produces the annual fleet-average operating cost savings. Annual savings are discounted to present value using a discount rate of 5%.

Fleet-average lifetime operating cost savings are calculated by taking the difference between the baseline and policy scenarios' sum of present values of all future fuel savings relative to the initial year of purchase. Subtracting the fleet-average incremental purchase price yields the net lifetime savings. Table V-5 shows the savings for just MY2025, however for all model years the net lifetime savings are positive, i.e. savings always exceed initial costs. Fleet-average monthly operating cost savings are calculated by summing the present values of future fuel savings over the loan period (assuming that vehicles are driven uniformly within a given year) and dividing by the loan period. For all model years the monthly savings exceed the increase in monthly payments.

Table V-5. Advanced Clean Cars Consumer Savings and Sensitivities for MY2025 Vehicles (2009 dollars)

Advanced Clean Cars	ISOR	3% Discount	7% Discount	w/ Sales Tax + Insurance
New MY2025 Vehicles				
Incr Vehicle Price	$1,906	$1,906	$1,906	$2,160
Incr Monthly Payment	$35	$35	$35	$40
Monthly Fuel Savings	$48	$51	$45	$48
Net Lifetime Savings	$4,043	$4,864	$3,370	$3,788
Payback Period (yrs)	2.9	2.8	3.1	3.4
10yr Old Used MY2025 Vehicles				
Incr Vehicle Price	$438	$438	$438	$497
Incr Monthly Payment	$14	$14	$14	$16
Monthly Fuel Savings	$36	$38	$35	$36
Net Lifetime Savings	$2,040	$2,220	$1,879	$1,982
Payback Period (yrs)	0.9	0.9	1.0	1.1

Finally, assuming a consumer purchases a new vehicle with cash, the relevant metric would be the years it takes the owner to recoup the initial investment, otherwise known as the payback period. Based on the discounted schedule of annual operating cost savings, a new MY2025 vehicle would payback in less than three years. The payback period is slightly higher for previous model years before the standards are full phased-in and operating cost savings are lower while vehicle technology costs are higher due to lower volumes; however for all model years the payback period remains below four years.

Calculations for used vehicles are conducted using similar methods. Ten-year old light-duty vehicles are assumed to retain 23 percent of their original value based on staff analysis of used vehicle values compiled by the National Automobile Dealers Association. Multiplying this percentage by the original incremental vehicle price yields the expected price increase for used vehicles. Monthly payments are calculating assuming a 10 percent interest rate for used vehicles based on data from the Federal Reserve. Due to their limited remaining life, loans for 10-year old vehicles are assumed to have a 36 month maturity period. For MY2025 vehicles at age 10 (i.e. in calendar year 2035) consumers could expect to pay an average of over $400 more for the vehicle, which translates to an increase of $14 more each month. However, like new vehicles, monthly and lifetime operating cost savings would substantially outweigh these vehicle costs, so that payback periods are significantly shorter.

As shown in Table V-5, the choice of different discount rates affects only the savings. A lower discount rate increases the value of the savings which in turn shortens the payback period, while a higher discount rate has the opposite effects. However, the discount rate does not substantially alter the payback period and in all cases the net savings remain positive.

ARB typically considers only the compliance costs (direct and indirect manufacturing costs) when evaluating economic impacts. From a consumer perspective, though, these higher compliance costs would also result in additional costs, namely higher sales tax and insurance costs. Adding the base California sales tax of 7.25% and the net present value of five years' worth of higher insurance premiums (6.6%, see section 0 below) for a more expensive vehicle would in turn increase the vehicle purchase price and monthly payments. However, lifetime savings would continue to outweigh the vehicle costs and payback periods would never exceed five years for all model years. In the monthly payment and savings comparison, some model years show payments for new vehicles exceeding expected savings, though the difference is less than $1 per month. The cause is largely the introduction of ZEV technologies. Note that the compliance costs for ZEVs do not include existing state and federal financial incentives. Given the expectation that they will continue in the near-term, these incentives should lower the purchase price sufficiently so that the fleet average monthly savings would exceed the increase in monthly payments. Thus, the inclusion of sales tax or insurance do not appreciably alter staff's conclusion that the proposed program would provide consumers with significant benefits.

This analysis relies on overall fleet averages. The actual savings that accrue to individual consumers will depend on their individual driving patterns as well as the price of fuel. Consumers with lower than average annual VMT would experience lower fuel savings than those presented above while consumers with higher than average VMT (or more energy intensive driving styles) would experience greater fuel savings. Likewise, if gasoline prices fall below current levels, fuel savings would be diminished, though the savings would still be favorable for vehicles that rely on gasoline. Similarly, higher gasoline prices would increase future fuel savings. However, individual consumers will make vehicle purchase decisions that maximize their own utility depending on their needs and habits as well as the attributes of the vehicles offered at the time of purchase.

VI. Modeling Consumer Response and Fleet Turnover

The proposed Advanced Clean Cars program is expected to reduce vehicle operating costs substantially, however initial purchase prices will be higher. While ARB staff has calculated the average payback period to be well within the average ownership period of the first owner, some stakeholders may contend that if vehicle prices increase too much, consumers would not purchase as many new (cleaner) vehicles. In turn, these consumers may keep their older (dirtier) vehicles longer which could erode some of the emissions benefits of the proposed amendments. This is often referred to as the potential "fleet turnover" effect.

To evaluate the potential extent of these fleet changes, ARB used a model (CARBITS) developed by researchers at the University of California, Davis to forecast the California fleet of new and used vehicles under different policy scenarios. CARBITS was initially developed for California's prior vehicle standards for greenhouse gases under AB 1493 (Chap. 200, Stats. 2002) that were approved in 2004. The model has subsequently undergone two revisions, the most recent (CARBITS 3.0) as part of a project evaluating the potential impacts of a feebate program on new vehicles. Further modifications to the model for this rulemaking are described below.

A. Model Overview

CARBITS is a response model of the California light-duty fleet based on discrete choice modeling theory. This latest version runs as an object-oriented program in MATLAB that takes as input vehicle attributes at the individual vehicle configuration level along with household demographic information; these inputs are used to calculate probabilities for the quantity and configuration of vehicles owned by California households over a multi-year period. The vehicle attributes relevant to vehicle choice include:

- Vehicle Body Type and Size (e.g. compact car, large pickup, etc.)
- Prestige level (as indicated by nameplate only)
- Fuel operating costs (as determined by combined MPG and fuel price projections in 2007 dollars)
- Performance (as measured by 0-60 acceleration time)
- Purchase Price (in 2007 dollars, coefficient differs by household income)

As is an option in the real world, households within CARBITS have the choice of owning new and/or used vehicles. The consumer preferences for the various vehicle attributes are based on revealed preference data of actual vehicle holdings among California households observed in the 2001 Caltrans Household Weekday Travel Survey, which indicate a high willingness-to-pay for reduced fuel operating costs. Individual household-level holdings are then aggregated using household weights to represent the statewide fleet. CARBITS produces total vehicle counts by body-type or EMFAC class and forecast year as well as more detailed breakdowns for twenty vintages within each forecast year. Additional output for different household types can also be generated, though was not used for this rulemaking. (See Bunch, et al., 2011 for complete model details.)

A panel of independent academics reviewed the methodology and inputs employed by CARBITS and concluded it to be an appropriate tool for this rulemaking and staff's interpretation of the results to be reasonable. The panel consisted of Prof. Steven Berry of Yale University, Prof. Roger von Haefen of North Carolina State University, and Dr. Melvyn Weeks of the University of Cambridge. The reviewers' feedback has been reflected in this appendix where applicable, while some comments related to further model testing and refinement have been reserved for future model development.

B. Model Modifications

For the most part, CARBITS 3.0 was used in the form for which it was developed for the feebate research project. The embedded behavioral model defining consumer preferences for different vehicle attributes was essentially unchanged as the model was estimated on California-specific data and more recent data are not available to serve as a basis for adjustments. Aside from the changes to generate the input data for different scenarios discussed below, the only substantive change to the model was the addition of another calibration constant so that vehicle totals in the early years would more closely match vehicle populations in EMFAC2011. Calibration is a common practice in modeling so that model estimates for past time periods will match with historical, empirical data.

CARBITS 3.0 was originally developed with three sets of calibration constants so the model projections would match historic vehicle distributions from DMV registration data and near-term vehicle sales projected as part of the feebate research project. Each set of calibration constants was intended for the shares of vintages of four different body types (car, truck, van, SUV) to match a given forecast year's distribution. For example, constants were calibrated so the projected 2001 vehicle population would have the same distribution of body types within the vintage groups 1982-1990, 1991-1999, 2000, and 2001 as in the DMV data. Similar constants were calibrated for the vintage groups 2002-2006 and 2008-2013 for later forecast years.

The calibration to shares resulted in near-term total vehicle counts and sales that were much higher than available current data due to the recession-related sales decline. Thus, for purposes of this rulemaking, an additional set of constants was calibrated so that near-term total vehicle counts would more closely match populations in EMFAC2011 (without regard to body type). These constants were based on the following vintage groups for forecast year 2013: 1988-1995, 1996-2001, 2002-2007, 2008-2009, 2010-2011, and 2012-2013. The vintage groups were defined in order to match the trends observed due to the recent economic recession and capture the historically low vehicle sales volumes during this period. No other adjustments are made for future forecast years or vintages.

C. Generating Input Files

CARBITS is designed to use only two user-specified input files: fuel price and vehicle attributes. Other parameters, such as model coefficients and household weights for the 65 household types, are viewable and changeable within the MATLAB environment but are not intended to be modified on a regular basis. For the purposes of this rulemaking analysis, only the two user-specified input files were modified and all other "hard-wired" parameters remained in their original form.

C1. Fuel Price File

As described in Section VII, gasoline fuel price projections were derived from the California Energy Commission's Transportation Energy Forecasts and Analyses for the 2011 Integrated Energy Policy Report (CEC, 2011). The CEC reports retail gasoline prices in 2009 dollars for a high and low case. ARB staff averaged the prices for the two cases and then converted to 2007 dollars (the dollar year used in CARBITS) using a CPI adjustment factor of 0.966 to yield the prices shown in Table V-2. The majority of CARBITS cases use the average value, though a few cases assume a price 30% higher than the average (which is slightly higher than the CEC high case) as well as a few cases using the CEC low case directly, also shown in Table V-2 (and then converted to 2007 dollars for CARBITS); each price forecast is used in its entirety for all forecast years. Fuel prices, combined with vehicle fuel economy, are used by CARBITS to calculate the fuel cost per mile for each vehicle configuration in a given year.

C2. Vehicle Attribute File

The vehicle attribute file contains information about future new vehicles. The information is specified at the vehicle configuration level for every model year beginning with 2011. (Attributes of vehicles of past model years are specified separately as these represent historic data that should not be modified.) A single make/model within a model year may have multiple configurations, for example some vehicles are available in either automatic or manual transmission, or as a sedan or hatchback; each unique combination of attributes is represented by a separate vehicle configuration. For MY2011, the CARBITS vehicle attribute file includes 795 unique vehicle configurations, which correspond to the new vehicle offerings for that model year. As part of the feebate research program, the vehicle attribute file was modified to account for the exit of certain vehicle configurations and the introduction of new vehicle configurations based on manufacturer announcements (see Bunch, et al., 2011), so that for MY2015-2025, each model year includes 985 vehicle configurations. Over the MY2011-2025 period, the original file provides attributes for 1136 unique vehicle configurations. ARB staff then assumes that all MY2025 configurations remain in the fleet through MY2030.

For evaluating this rulemaking, only vehicle prices and fuel operating costs are adjusted, and other attributes such as horsepower or weight[12] are assumed to remain unchanged over the forecasting period for all scenarios. While such an assumption may not be consistent with historic trends showing performance and size metrics steadily increasing with time, for purposes of isolating the potential effects as a result of only the proposed amendments, staff believes this to be a reasonable approach. ARB is expressly prohibited from regulating vehicle weight or size and staff believes that automakers are unlikely to risk market share by reducing performance from current levels to achieve emissions targets. Additionally, the estimated compliance costs incorporate the costs for maintaining performance characteristics, e.g. downsized engines have direct injection and turbocharging. The implementation of the proposed program is assumed not to affect other exogenous factors, such as fuel prices or demographic trends, which are consistent across all scenarios.

Vehicle prices are adjusted based on the incremental costs estimated for the various compliance scenarios that include the costs associated with generating air conditioning credits. These costs are originally presented relative to MY2008 vehicles beginning

[12] While it is possible that some automakers may choose to reduce vehicle mass beyond already planned reductions and receive a compliance benefit in doing so, consumers are not modeled to have preferences for vehicle mass per se but for acceleration time (0-60 mpg) which is calculated using vehicle mass as one of the variables. Thus, if mass is decreased but all other parameters remain constant, acceleration time would improve, making the vehicle more attractive to consumers. However, it is possible that commensurate with the decrease in vehicle mass other attributes such as horsepower may also be scaled back leaving the overall acceleration time the same as before. For simplicity, to ensure that acceleration time remains unaffected, the input variables to calculate this parameter are held constant.

with compliance with MY2012 standards. Although light-duty vehicles are not subject to new federal GHG emission standards until MY2012, the incremental costs for MY2009-2011 are linearly interpolated with the expectation that manufacturers have introduced control measures in advance of the start of the National Program. Different sets of incremental costs are then applied for the various policy analysis scenarios in the following manner.

Over 500 vehicle configurations expected in the future fleet were also offered for sale in MY2008. For these configurations, the estimated incremental cost is simply converted from 2009 dollars to 2007 dollars using the CPI adjustment factor of 0.966 and then added to the MY2008 vehicle price to estimate the purchase price of future model years compliant with the proposed amendments. (See Table VI-1) Note that purchase prices are influenced by other factors, both market driven and for compliance with other types of regulations, which are not included in these incremental cost estimates in order to isolate the effects of the proposed policies. For all scenarios, incremental costs are assumed to decrease at an annual rate of two percent after MY2025 to account for reductions due to learning as is consistent with the assumptions of the technology assessment used to derive the compliance costs.

Purchase prices of vehicle configurations that are introduced after MY2008 are adjusted using incremental cost increases that are relative to their year of introduction. For example, if a new MY2009 vehicle is expected to be $100 more than a MY2008 vehicle, and a MY2010 vehicle is $250 more than the base MY2008 vehicle, the purchase price of a vehicle introduced in MY2009 would be assumed to have already incorporated any necessary adjustments to comply with California's GHG standards upon its entry into the market and therefore have zero incremental cost added in its first year. However, in the next model year, MY2010, its vehicle price would increase relative to MY2009, i.e. $150 ($250 minus $100). Essentially, for new vehicles introduced after MY2008, initial vehicle prices are assumed to have already included the compliance costs that previously existing vehicles would have had added in that year of introduction. The incremental costs relative to MY2008 vehicles that serve as the basis for these adjustments are presented in Table VI-1.[13]

[13] Note that mathematically, creating a baseline and policy set of input files that are both relative to MY2008 is equivalent to creating a baseline file relative to MY2008 and a policy file that is relative to the newly created baseline, the latter being how the adjustments were described in Section IX of the ISOR. Also note that values are presented in 2007 dollars, which is the dollar year used by CARBITS, and differs from the values in the ISOR presented in 2009 dollars.

Table VI-1. Fleet Average Incremental Vehicle Price Adjustments Relative to MY2008 Passenger Cars and Light Trucks (2007 dollars)

MY	Baseline	Advanced Clean Cars Program	LEV III Program Only
2008	$0	$0	$0
2009	$165	$165	$165
2010	$329	$329	$329
2011	$494	$494	$494
2012	$658	$658	$658
2013	$750	$750	$750
2014	$907	$907	$907
2015	$1,227	$1,232	$1,232
2016	$1,307	$1,321	$1,321
2017	$1,349	$1,522	$1,535
2018	$1,474	$1,869	$1,831
2019	$1,354	$2,069	$1,887
2020	$1,289	$2,240	$2,028
2021	$1,275	$2,520	$2,203
2022	$1,254	$2,728	$2,355
2023	$1,229	$2,894	$2,445
2024	$1,212	$3,061	$2,546
2025	$1,116	$2,962	$2,484
2026	$1,093	$2,903	$2,434
2027	$1,072	$2,845	$2,385
2028	$1,050	$2,788	$2,337
2029	$1,029	$2,732	$2,291
2030	$1,009	$2,678	$2,245

As shown in Table VI-2, most vehicle configurations announced by manufacturers previously would be introduced prior to the start of the National Program. However MY2013 is expected to feature many new configurations. While the federal government had yet to adopt the National Program at the time these configurations were announced, the Energy Independence and Security Act of 2007 (EISA) would have been in place so these vehicle configurations would have accounted for some of the modifications necessary to comply with the newer standards. Given that these MY2013 vehicle configurations are introduced in the early phases of the National Program, and that these configurations represent a minority of the overall vehicle offerings, staff does not expect the difference between the EISA and National Program requirements during this period to have any significant effect on the policy analysis. Furthermore, because the same assumptions would apply in both the baseline and policy cases, any impacts would effectively cancel out in the comparison between the two scenarios.

Table VI-2. Distribution of Vehicle Configuration Introductions

Model Year Introduced	Number of Configurations
2008 or earlier[14]	673
2009	43
2010	41
2011	38
2012	58
2013	250
2014	31
2015	2
Total Configurations	1136

The incremental prices are added to the MY2008 vehicle prices (or the rescaled incremental prices are added to vehicle prices for new introductions) to obtain future vehicle purchase prices through MY2030. In the primary analysis, each vehicle configuration's purchase price reflects the average compliance costs for the overall fleet, even though the vehicle configurations with the CARBITS choice set of alternatives are almost exclusively gasoline internal combustion or conventional hybrid technology (i.e. non-plug-in hybrids). Staff believes this is a reasonable assumption as internal cross-subsidization of vehicles within a manufacturer's fleet is not an uncommon practice. So it is possible that automakers would transfer some of the higher compliance costs associated with advanced vehicle technologies required by the ZEV amendments onto conventional vehicles. Given the uncertainty of future vehicle pricing decisions automakers may choose to make, using the overall fleet average price increase is a more conservative assumption than using the (lower) average price increases for gasoline-only vehicles. Sensitivity analysis using alternative incremental price changes was conducted to determine the importance of this assumption.

Fuel consumption of vehicle configurations is likewise adjusted relative to either MY2008 levels or the year of introduction. Due to the existing wide variety in energy intensity of vehicles, attributing the average value implied by the emissions standards to all configurations did not seem to be a reasonable approach. Instead, fuel consumption rates are adjusted by the percent reduction in the average emission rates for a future model year relative to the configuration's base year. The reductions are calculated based on the values shown in Table VI-3 for tailpipe test cycle average greenhouse gas

[14] Not all configurations introduced prior to MY2008 remain in the fleet.

emission of non-Zero Emission Vehicles (ZEV)[15] before crediting for air conditioning improvements that also reduce GHGs as estimated by staff. The vehicle configurations in the attribute file are almost exclusively internal combustion or conventional hybrid technologies (i.e., non-plug-in hybrids) that use only gasoline as their energy input. Although the price adjustments reflect changes to the overall fleet, the overall tailpipe emission rates would not convert appropriately to operating costs due to the mix of future vehicle technologies with different carbon intensities. However, operating costs of ZEVs are expected to be comparable if not much lower than those of non-ZEVs, so adjusting based on non-ZEV technology improvements is a conservative assumption.

Table VI-3. Test cycle Average Emissions of non-ZEV type Passenger Cars and Light Trucks (grams of CO2-equivalent per mile)

	Baseline		Advanced Clean Cars Program		LEV III Program Only	
MY	PC	LT	PC	LT	PC	LT
2008	291	396	291	396	291	396
2009	285	388	285	388	285	388
2010	279	380	279	380	279	380
2011	272	371	272	371	272	371
2012	266	363	266	363	266	363
2013	271	358	271	358	271	358
2014	257	342	257	342	257	342
2015	243	327	243	327	243	327
2016	232	315	232	315	232	315
2017	230	317	223	305	225	309
2018	230	317	219	298	219	300
2019	230	316	214	290	212	289
2020	230	317	210	285	204	277
2021	229	317	203	275	196	265
2022	229	317	198	267	188	253
2023	229	317	194	260	182	243
2024	229	316	190	252	176	234
2025	229	316	182	239	170	225
2026	229	316	182	239	170	225
2027	229	316	182	239	170	225
2028	229	316	182	239	170	225
2029	229	316	182	239	170	225
2030	229	316	182	239	170	225

[15] ZEVs here refer to plug-in hybrid electric vehicles, full battery electric vehicles, and hydrogen fuel cell vehicles.

D. Scenario Outputs

Although CARBITS is capable of producing projections for each of the vehicle configurations, the level of resolution in choice alternatives is to allow for greater variation in attribute adjustments rather than generating results for any individual vehicle configuration. Results for each vehicle configuration are thus aggregated into fleet-wide metrics. The most aggregated output files show the total number of vehicles for every forecast year broken down only by vehicle classes: general body types car, van, truck, SUV; or EMFAC classes PC, T1, T2, T3. The less aggregated output file shows the total number of vehicles broken down by either of the two vehicle classification schemes and further disaggregated by vintage. Generally, the format analyzed to facilitate evaluation of emissions impacts is the output file (op3) in which vehicles are delineated by vintage and EMFAC class. (See Appendix T for further details on using CARBITS output to calculate emissions impacts.) Emission impacts were quantified only for the baseline and main policy scenarios as discussed in Section IX. For the sensitivity cases described below, emissions impacts are discussed only qualitatively relative to these primary scenarios.

For each primary scenario, three metrics are presented to characterize the fleet's composition and the potential emissions implications. First is the total fleet size. A growing fleet implies that new vehicles with lower emissions are continuing to be sold; a stagnant fleet size would be ambiguous as to whether new vehicles are entering or whether older vehicles are being held longer. This fact can be confirmed by the second metric, new vehicle sales. New vehicle sales are defined here as the number of vehicles of the vintage equal to the forecast year, e.g. the number of MY2016 vehicles in forecast year 2016.[16] The relative proportion of new vehicle sales to the total fleet is characterized by the third metric, average vehicle age. This value is calculated by assigning a vehicle age of 1 for a vintage when it first becomes available, as is consistent with EMFAC. The average age is then weighted by the number of vehicles of each vintage. A declining average age implies that new vehicles are entering the fleet at a greater rate than older vehicles are exiting. To the extent that newer vehicles will have lower emission rates associated with them, a lower average age would be associated with lower overall emissions.

These metrics are generated for the purpose of policy analysis as opposed to market forecasting. Vehicle sales volumes and distributions are influenced by a host of factors, notably fuel prices, broader economic conditions, and consumer tastes. In this analysis,

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[16] CARBITS is technically calibrated to vehicle populations that are part of an open system. A vintage may not reach its maximum population in the first year due to straggling sales, e.g. MY2016 vehicles that do not sell until 2017, or through migration of vehicles when people move into the state. However, vehicles that may have been purchased early in the model year are assigned to the equivalent forecast year, e.g. MY2016 vehicles purchased in 2015 are assumed to have been purchased in 2016.

these other factors are implicitly assumed to remain unchanged with and without the proposed amendments in order to isolate the effects of the policy. Such conditions are unlikely to exist in reality so that actual fleet dynamics are likely to deviate from these projections. Thus, the differential between the policy case and baseline serves as the most relevant indicator for assessing the scale and direction of the impacts, which is the main objective for this analysis.

D1. Baseline

A baseline future fleet mix for the years 2015-2030 is first forecast that assumes that, absent the proposed amendments, vehicle prices and operating costs change only in response to the existing National Program requirements for MY2012-2016 using the methods and inputs described above.[17] Table VI-4 shows the results that serve as the basis for comparison of all policy scenarios.

Table VI-4. Results of Baseline Scenario

Year	Baseline Scenario		
	Vehicle Sales (x1000)	Fleet Size (x1000)	Average Age[18] (years)
2015	1,784	20,032	7.8
2016	1,834	20,323	7.6
2017	1,795	20,627	7.5
2018	1,749	20,928	7.4
2019	1,726	21,239	7.3
2020	1,701	21,532	7.3
2021	1,681	21,836	7.3
2022	1,660	22,150	7.3
2023	1,645	22,452	7.4
2024	1,633	22,737	7.5
2025	1,629	23,006	7.6
2026	1,622	23,243	7.7
2027	1,615	23,465	7.8
2028	1,607	23,703	7.9
2029	1,603	23,945	8.1
2030	1,602	24,142	8.2

[17] MY 2012-2016 National Program compliance is assumed as the baseline because all manufacturers subject to California's 2012-2016 GHG standards have exercised their option to use National Program compliance to serve as compliance with California standards.

[18] A new vehicle is defined as having an age of 1, which is consistent with EMFAC.

D2. Policy Scenarios

a) Advanced Clean Cars Program

The primary policy case evaluated assumes that the light-duty fleet in California is compliant with the entire Advanced Clean Cars (ACC) program, i.e. both the LEV III and ZEV amendments.[19] Table VI-5 shows the results for this policy scenario and the difference in fleet characteristics from the baseline. In the initial years of the regulation there is a negligible decrease in sales due to compliance with the criteria pollutant standards while there is no concurrent reduction in operating costs resulting from these proposed amendments. However, once the greenhouse gas standards begin to phase in during MY2017, the reduced operating costs of new vehicles makes them more attractive to consumers and total sales begin to increase despite increased initial new vehicle prices. Sales continue to grow over the baseline until the standards have been fully phased-in in MY2025. After this point, new vehicles no longer offer any significant advantage in operating costs over used vehicles that become increasingly available on the market. Thus, the change in sales begins to decline, though these levels still represent a relative increase over baseline totals. As a result of these sales, the fleet continues to grow slowly with time, making the regulation scenario fleet larger in all years compared to the baseline fleet. These sales increases also contribute to decreasing the average age of the fleet, implying that households are not holding onto their older vehicles longer.

A reminder that all of these results were generated assuming that only vehicle prices and operating costs are changing with time. Historical trends indicate that automakers will likely continue to innovate on a variety of vehicle attributes for competitive reasons which are not modeled here. Therefore, while the CARBITS results show declining sales in the long-term, if other attributes valued by consumers are enhanced after the standards have phased-in, sales would likely remain stable or increase gradually. Evaluation of the emissions impacts of these changes in fleet composition indicates that the program benefits would continue to be positive.

[19] Amendments to the Clean Fuels Outlet regulations, also part of the proposed Advanced Clean Cars program are assumed to provide hydrogen stations for fuel cell vehicles expected as a result of the ZEV amendments but have no impact on this analysis because infrastructure availability is not explicitly modeled as a decision factor for vehicle purchases.

Table VI-5. Results of ACC Policy Scenario

Year	ACC Policy Scenario			Difference from Baseline Scenario		
	Vehicle Sales (x1000)	Fleet Size (x1000)	Average Age (years)	Vehicle Sales (x1000)	Fleet Size (x1000)	Average Age (years)
2015	1,784	20,032	7.8	0	0	0.0
2016	1,833	20,323	7.6	-1	0	0.0
2017	1,859	20,640	7.5	64	13	0.0
2018	1,827	20,960	7.3	78	32	-0.1
2019	1,819	21,296	7.2	93	57	-0.1
2020	1,804	21,620	7.2	102	88	-0.1
2021	1,809	21,963	7.1	128	128	-0.2
2022	1,802	22,324	7.1	141	174	-0.2
2023	1,796	22,677	7.2	151	225	-0.3
2024	1,791	23,019	7.2	158	282	-0.3
2025	1,848	23,361	7.2	219	355	-0.4
2026	1,816	23,675	7.3	194	432	-0.4
2027	1,787	23,974	7.3	172	509	-0.5
2028	1,759	24,284	7.5	152	581	-0.5
2029	1,735	24,593	7.6	133	648	-0.5
2030	1,717	24,862	7.7	116	720	-0.5

b) LEV III Amendments Only

While the Advanced Clean Cars program is ARB’s preferred policy approach, the LEV III program could stand alone in the event that the ZEV amendments are not adopted. In this case, there would be fewer ZEV-type vehicles in the fleet (not zero, as current ZEV requirements are assumed to remain in effect), which would imply that non-ZEVs would need more technology to achieve the same fleet average emission rates. This would result in vehicles having a relatively lower incremental vehicle cost as well as a greater reduction in fuel operating costs than the ACC scenario. As a result, while the overall trend relative to the baseline is similar, vehicle sales and fleet size are higher than they are under the ACC Policy Scenario – and correspondingly average age declines further – making the ACC Policy Scenario the more conservative of the two policy scenarios in that the fleet would turnover more slowly. Figure VI-1, Figure VI-2, and Figure VI-3 show how the two scenarios differ along the three main metrics in absolute terms and relative to the baseline scenario.

Figure VI-1. Comparison of New Vehicle Sales Estimates

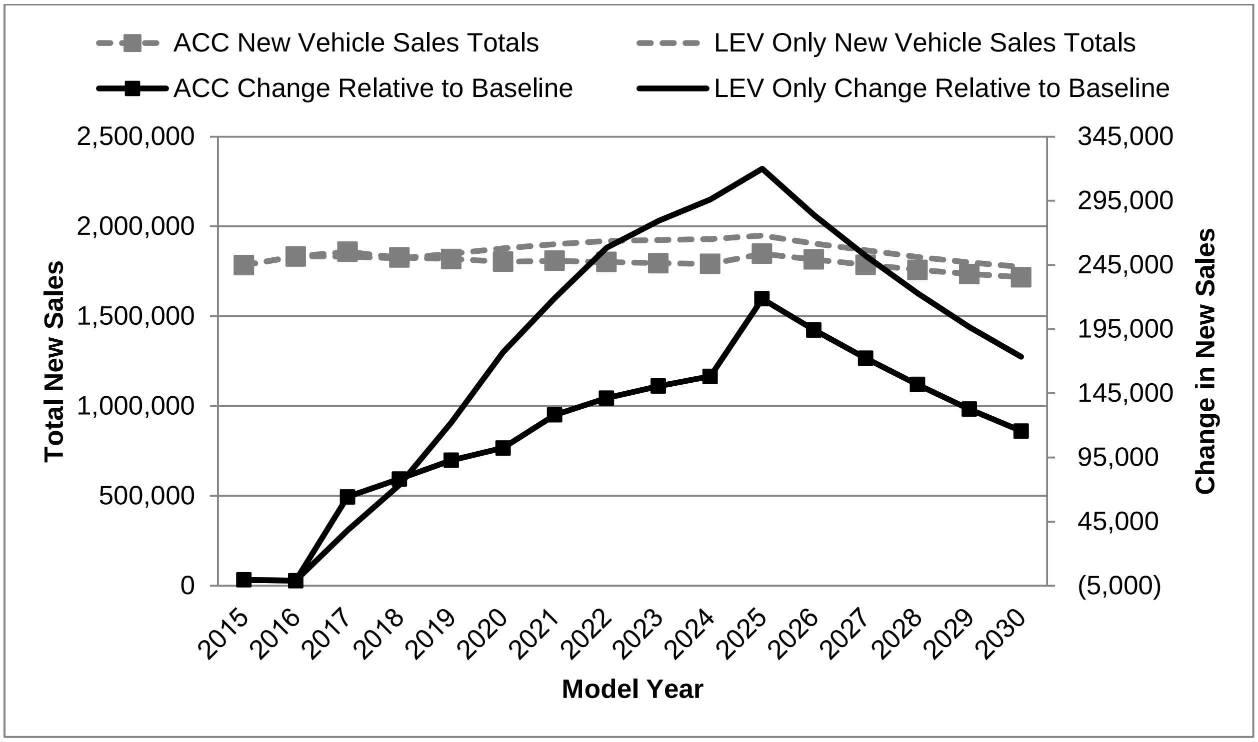


Figure VI-2. Comparison of Total Fleet Size Estimates

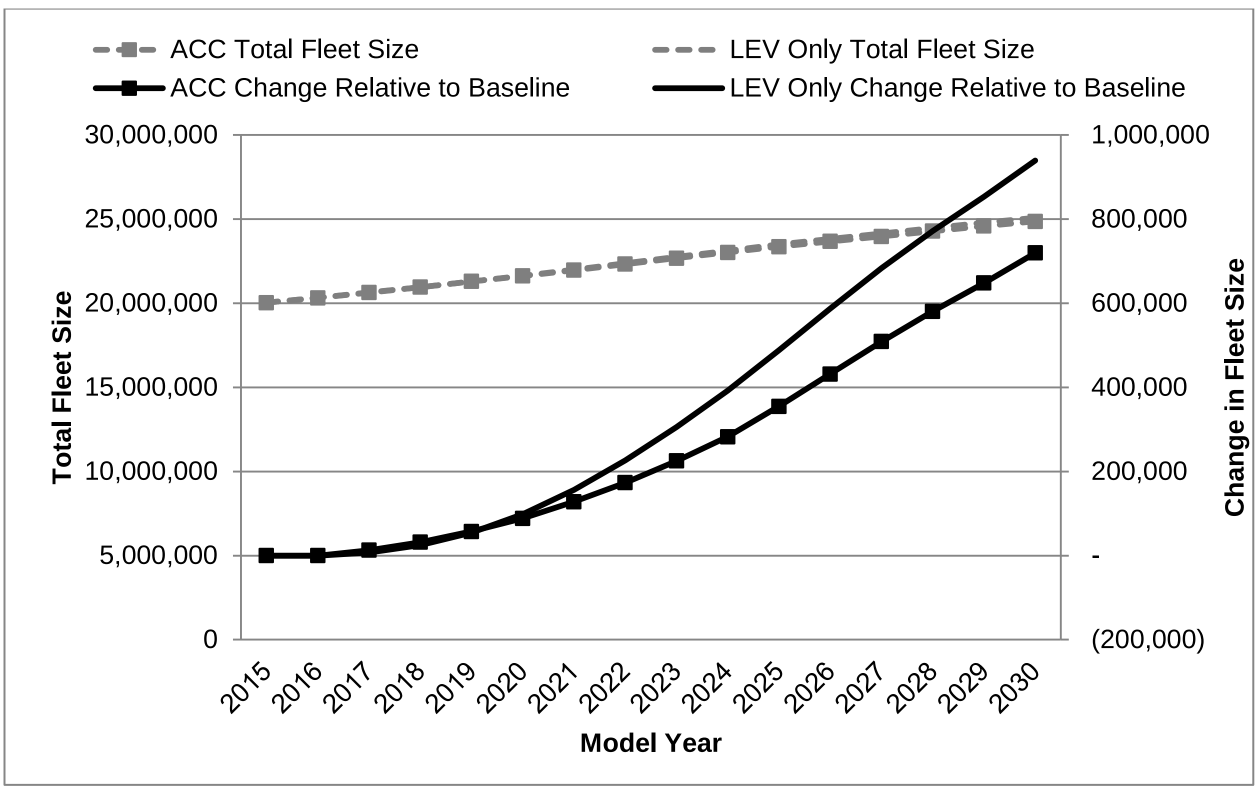
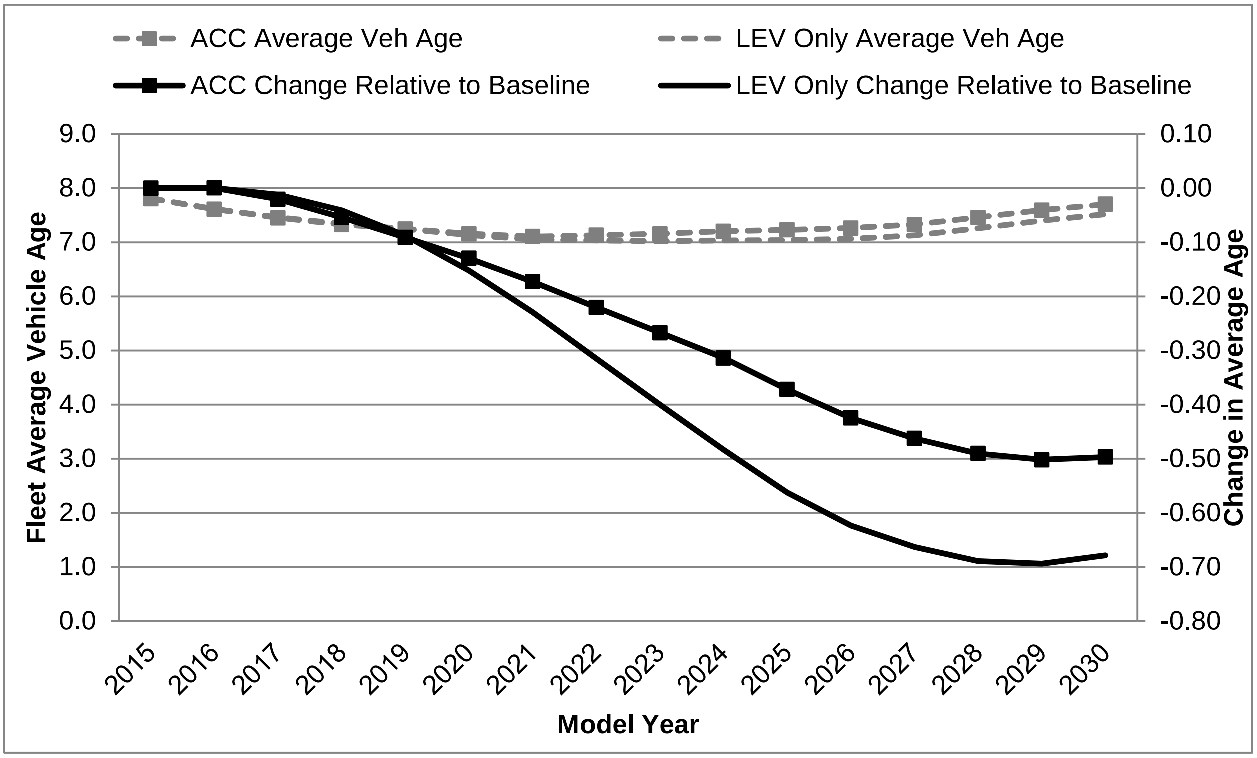


Figure VI-3. Comparison of Average Vehicle Age Estimates



D3. Impact on Criteria Pollutants

ARB staff used the fleet composition generated by CARBITS for the Advanced Clean Cars scenario in a modified emissions inventory tool to estimate the changes in criteria pollutant emissions. The CARBITS population reflects only twenty vintages of light-duty vehicles in any calendar year and therefore represents a subset of the EMFAC population used for the emission reductions presented in Section V-D of the ISOR. The emissions estimates from the two models are therefore not necessarily expected to match exactly, however the CARBITS subset covers over 90 percent of vehicles in the on-road light-duty fleet and their associated VMT so the differences are not significant.

In addition to a Baseline emissions profile for the CARBITS subset, two different ACC Policy scenarios are evaluated. One set is analogous to the emissions benefits described in in Section V-D of the ISOR which do not include any consumer response to new vehicle offerings. These results reflect the changes only from improvements in tailpipe emission rates and assume there are no changes in fleet composition, though do account for any emissions increases due to the rebound effect. Allowing for a different fleet mix as a result of ACC yields the results with consumer response. In this case, the distribution of vehicles not only includes a greater share of newer vehicles but also more vehicles total to result in a larger total fleet. Total emissions are a function of both the vehicle emission rates and the number of miles that vehicles are driven. While newer vehicles will have lower emission rates, separate from the expected increase in

VMT due to the rebound effect resulting from the lower operating costs, newer vehicles also tend to be driven more intensively in their younger years. Thus, having a greater proportion of newer vehicles and a larger total fleet size would generate additional VMT as an artifact of the modeling methodology.

As shown in Table VI-6 NOx emissions would be essentially unchanged when accounting for consumers response to new vehicle offerings. ROG and PM2.5 emissions show more of an effect, though in opposite directions. Table VI-7 shows that consumer response actually enhances emission reductions of ROG by a few percentage points. In contrast, Table VI-8 shows that consumer response could slightly reduce some of the expected emission reductions of PM2.5 as a result of an increase in VMT. In the event that total fleetwide VMT is solely a function of the rebound effect, renormalizing VMT to account only for those effects but maintaining the changes in fleet composition would result in identical changes for all pollutants shown for the ACC without consumer response scenarios in the tables below. Thus, on balance the program would continue to produce net benefits for all pollutants even when allowing for changes in fleet composition. The emissions impacts based on the CARBITS populations are consistent with the reductions estimated in Section V of the ISOR, as shown by the blue curves in Figure VI-4, Figure VI-5, and Figure VI-6 below.

Table VI-6. NOx Reductions from Advanced Clean Cars With and Without Consumer Response (tons per day)

	Baseline	ACC without Consumer Response		ACC with Consumer Response	
Year	Tons per day	Tons per day	% Reduction	Tons per day	% Reduction
2015	107.8	107.6	0%	107.6	0%
2016	96.5	95.7	1%	95.7	1%
2017	88.1	86.2	2%	86.2	2%
2018	81.1	78.0	4%	77.9	4%
2019	76.2	71.7	6%	71.5	6%
2020	72.5	66.1	9%	65.8	9%
2021	69.3	60.8	12%	60.5	13%
2022	67.4	56.4	16%	56.1	17%
2023	65.7	52.0	21%	51.8	21%
2024	66.5	50.0	25%	49.8	25%
2025	67.3	47.9	29%	47.6	29%
2026	67.9	45.5	33%	45.2	34%
2027	68.5	43.4	37%	43.1	37%
2028	69.1	41.6	40%	41.3	40%
2029	69.7	39.9	43%	39.7	43%
2030	70.2	38.2	46%	38.2	46%

Table VI-7. ROG Reductions from Advanced Clean Cars With and Without Consumer Response (tons per day)

	Baseline	ACC without Consumer Response		ACC with Consumer Response	
Year	Tons per day	Tons per day	% Reduction	Tons per day	% Reduction
2015	89.9	89.8	0%	89.8	0%
2016	79.8	79.6	0%	79.6	0%
2017	72.6	72.0	1%	71.9	1%
2018	68.1	67.2	1%	66.8	2%
2019	65.0	63.5	2%	63.0	3%
2020	62.5	60.1	4%	59.4	5%
2021	60.7	57.3	6%	56.3	7%
2022	60.3	55.5	8%	54.3	10%
2023	60.1	53.7	11%	52.2	13%
2024	61.0	52.7	14%	50.9	17%
2025	62.4	51.7	17%	49.6	21%
2026	63.8	50.3	21%	47.8	25%
2027	65.3	48.7	25%	46.0	29%
2028	67.3	47.6	29%	44.7	33%
2029	69.3	46.3	33%	43.4	37%
2030	70.7	44.3	37%	41.5	41%

Table VI-8. Total PM2.5 Reductions from Advanced Clean Cars With and Without Consumer Response (tons per day)

	Baseline	ACC without Consumer Response		ACC with Consumer Response	
Year	Tons per day	Tons per day	% Reduction	Tons per day	% Reduction
2015	19.4	19.4	0%	19.3	0%
2016	19.9	19.9	0%	19.8	0%
2017	20.3	20.3	0%	20.2	1%
2018	20.7	20.6	0%	20.6	0%
2019	21.0	20.8	1%	20.9	1%
2020	21.3	21.0	1%	21.1	1%
2021	21.6	21.2	2%	21.3	1%
2022	21.9	21.3	3%	21.5	2%
2023	22.1	21.5	3%	21.7	2%
2024	22.3	21.6	3%	21.9	2%
2025	22.5	21.7	4%	22.1	2%
2026	22.7	21.6	5%	22.2	3%
2027	22.9	21.5	6%	22.2	3%
2028	23.0	21.4	7%	22.1	4%
2029	23.2	21.4	8%	22.1	4%
2030	23.3	21.3	8%	22.1	5%

Figure VI-4. NOx Reductions from Advanced Clean Cars With and Without Consumer Response (percent)

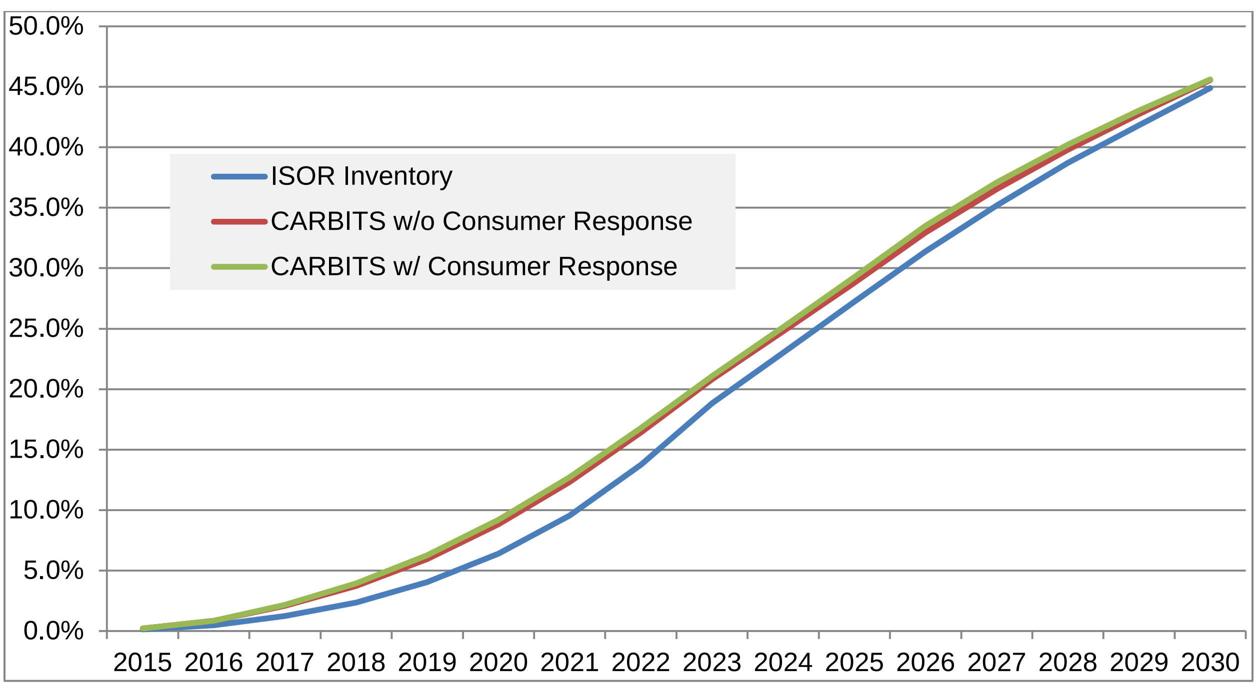


Figure VI-5. ROG Reductions from Advanced Clean Cars With and Without Consumer Response (percent)

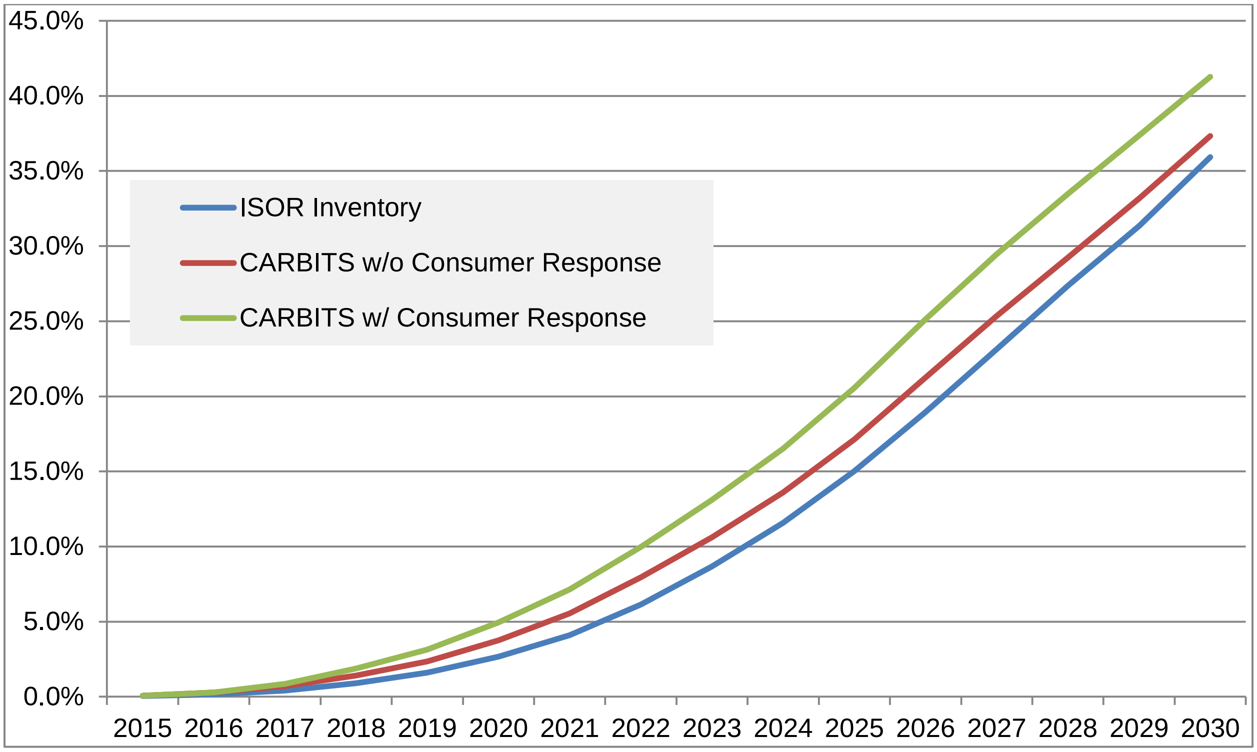
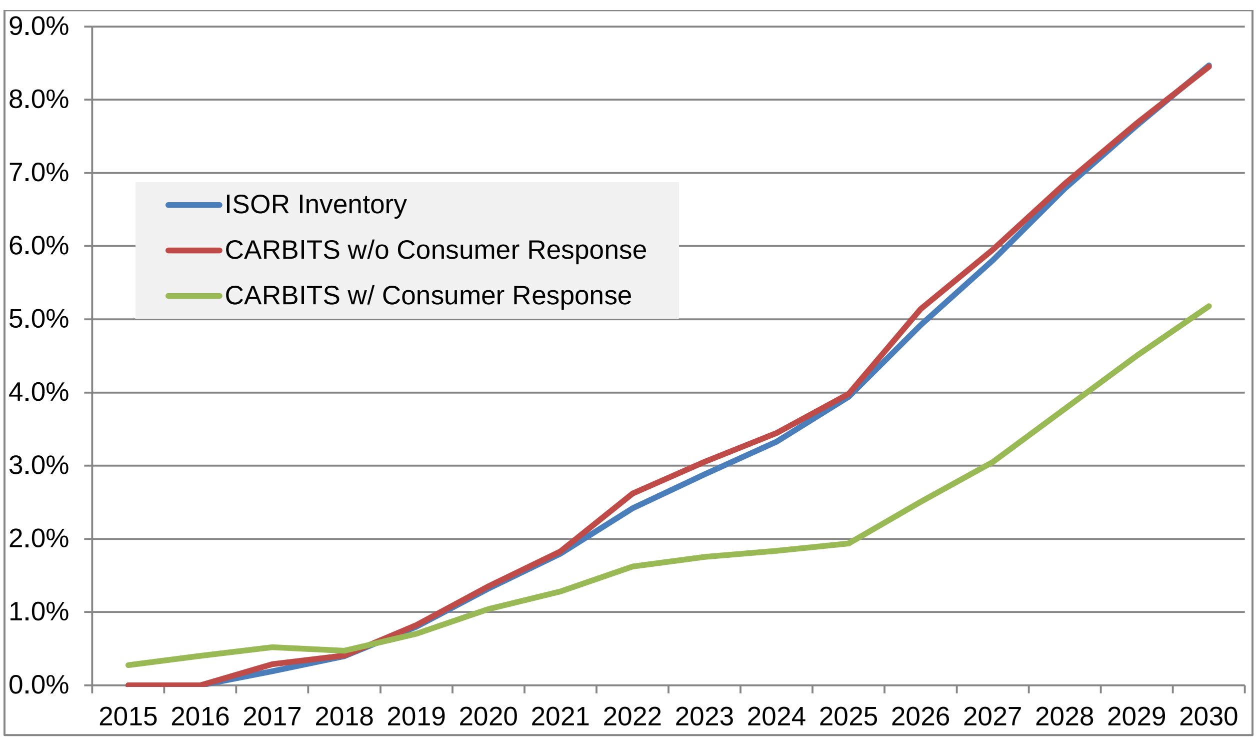


Figure VI-6. Total PM2.5 Reductions from Advanced Clean Cars With and Without Consumer Response (percent)



Only the emissions for the Advanced Clean Cars policy scenario were quantified. In the event that the LEV III amendments are adopted in isolation, the emissions reductions would be similar as the fleet average standards for criteria pollutants would remain unchanged. Under the LEV III Only scenario, new vehicle sales are slightly greater and fleet turnover more accelerated than the ACC scenario, which could accentuate some of the differences between the with and without consumer response scenarios. However, the difference between the two policy scenarios remains much smaller than the difference between the baseline and policy case, so staff does not believe the difference in emissions will be significant.

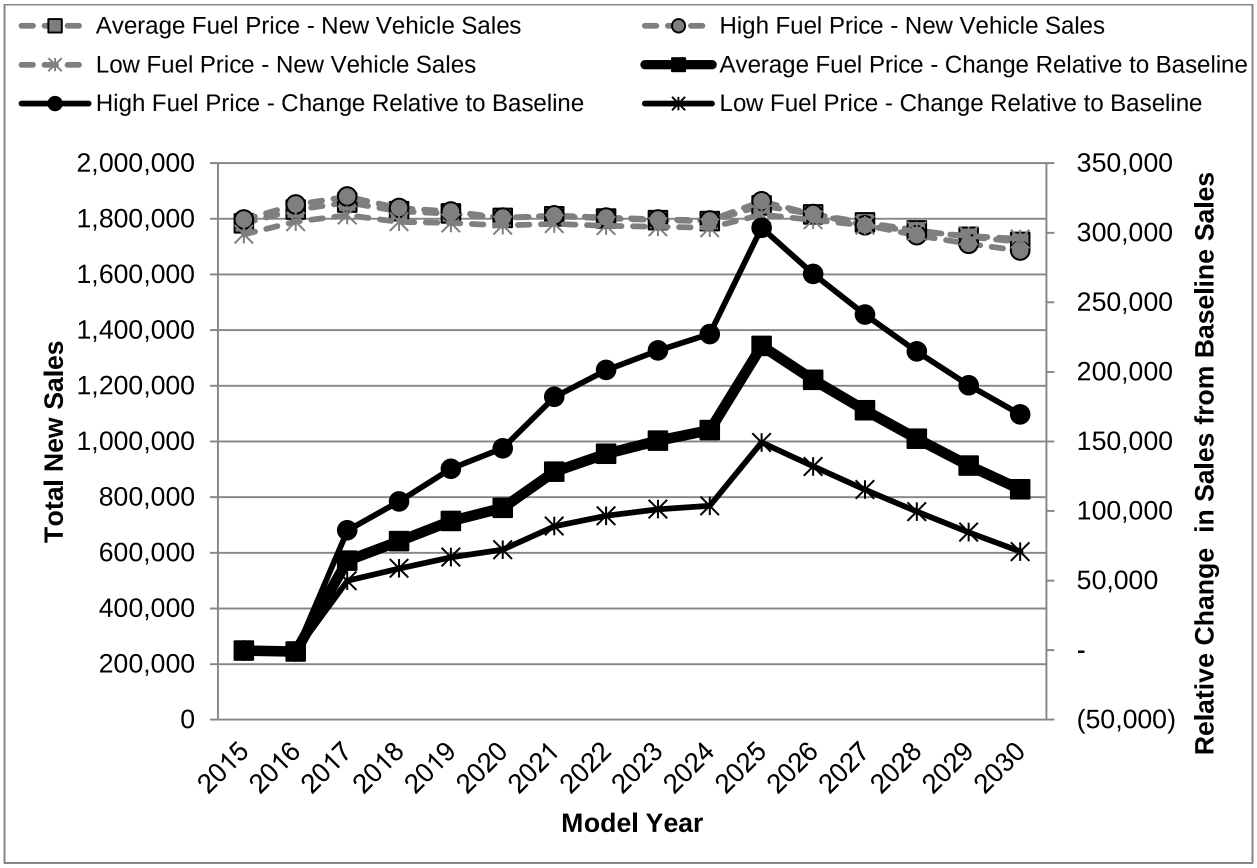
E. Sensitivity Analysis

E1. Alternative Fuel Price Cases

Due to the recent volatility in gasoline prices, a few cases were run using higher and lower fuel price schedules shown in Table V-2. The 30% higher than average alternative was developed as purely hypothetical to illustrate the potential effects on California's fleet composition if fuel prices increase slightly more than currently forecasted but vehicle technology improved at the same rate and cost as described previously. Given that ARB does not assume that its policies will reduce gasoline demand sufficiently to have any influence on global oil prices, changes to fuel prices would affect the results of both the baseline and policy scenarios.

Figure VI-7 shows the sensitivity of new vehicle sales to assumptions about fuel price. In the case where fuel prices are 30 percent higher than the average price assumed in the primary analysis, new vehicles sales totals for the proposed Advanced Clean Cars program would be fairly similar to the totals of the primary analysis. However, as the baseline scenario would differ due to the higher fuel price assumption, the relative difference between the baseline and policy scenario would be slightly greater. The change to the baseline can be attributed to the fact that the behavioral model embedded in CARBITS evaluates changes in operating cost regardless of whether those changes occur due to changing fuel prices or changing vehicle technology. An increase in fuel prices will proportionally increase operating costs assuming that vehicle technology remains the same. Additionally, while the percentage increase in operating costs is the same for both cases, the absolute increase is higher for the baseline (i.e. 30 percent of a larger number will be larger). Meanwhile, the incremental vehicle prices of future model years remains unchanged for both cases.

Figure VI-7. Sensitivity of New Vehicle Sales Estimates to Fuel Prices



While the standards are still being phased in, the improvements in vehicle technology will outweigh the effect of higher fuel prices, so that operating costs would continue to decrease with each new model year on a cents per mile basis. This effectively makes new vehicles more attractive to consumers and in this way helps to insulate new vehicle sales from the higher fuel prices. In the baseline scenario, the GHG emission standards plateau after MY2016, leaving almost all new vehicles in that scenario with incremental vehicle prices that buy less operating cost reductions and new vehicles are not as attractive as they would have been assuming the average fuel price forecast.

New vehicle sales in the High Fuel Price Baseline are therefore slightly lower than they are in the Average Fuel Price Baseline after MY2016. The relative reduction in new sales contributes to a relative shrinking of the fleet and a relative reduction in the average age of the fleet, implying that older vehicles are also exiting the fleet at a greater rate when there are higher fuel prices. Such a result is not unexpected given that older vehicles would have much higher operating costs under a high fuel price scenario, making them less appealing to own. Comparing the baseline and policy scenarios shows that the propose program would lead to an even younger fleet, implying lower total emissions than there would have been assuming average fuel prices.

A similar comparison was made assuming that fuel prices follow the CEC Low Price forecast. Under this assumption, the proposed Advanced Clean Cars program would result in lower new vehicle sales than the proposed program would using the average fuel price assumption. In this case, while the lower fuel prices will further contribute to lower operating costs of new vehicles which comply with the proposed program, the fuel price assumption also lowers the operating costs of existing used vehicles. Thus, the benefits of purchasing a new vehicle would be diminished.

This slower influx of new vehicles would in turn increase the size of the overall fleet. As a result, while the average age of a vehicle would decline, the decrease would be smaller than under the average fuel price case. A fleet that is larger and older could imply reduced emissions benefits than those projected in the primary analysis. However, the baseline scenario would also be affected by the change in the fuel price assumption. This fleet is also somewhat larger and older than the baseline assuming average fuel prices. The difference between these two scenarios continues to suggest that relative to the baseline, the proposed program would yield net emissions benefits as the fleet would still be relatively younger than the baseline.

Overall, although the interaction between the proposed program and fuel prices will have an important role in the magnitude of emissions reductions, the relative differences from the baseline case would suggest net emission reductions in all cases regardless of the fuel price assumption.

E2. Alternative Incremental Vehicle Price Adjustments

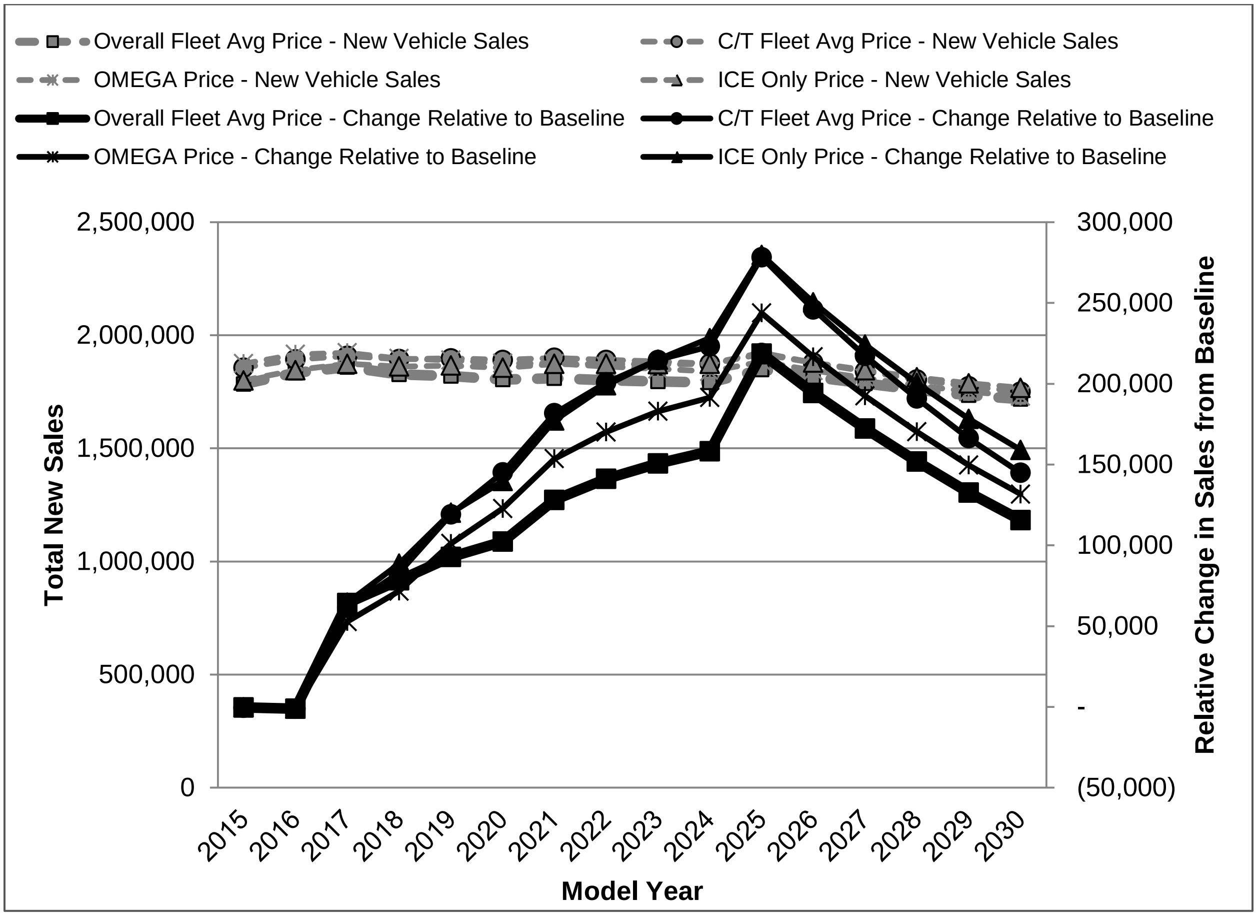
The behavioral model embedded in CARBITS was estimated based on consumer preferences for vehicles that were actually available in the market at the time of data collection. The choice set of alternatives within CARBITS for future forecast years is likewise based on known options at the time of the model's development and therefore almost exclusively gasoline internal combustion or conventional hybrid technology (i.e. non-plug-in hybrids). In the primary analysis, each vehicle configuration's purchase price is adjusted assuming the overall sales-weighted fleet average compliance costs for all technology types allowing for the potential internal cross-subsidization of vehicles within a manufacturer's fleet. However, vehicle price adjustments may vary by passenger car (PC) or light truck (LT) category.

To evaluate the potential effects of this assumption, ARB applied the sales-weighted fleet average incremental vehicle prices by vehicle category shown in Table VI-9 to each vehicle configuration. The higher PC prices reflect the fact that all ZEVs are assumed to fall into this vehicle category, while LT prices reflect only the costs associated with non-ZEV technologies. Operating cost adjustments remain the same.

Table VI-9. Incremental Vehicle Price Adjustments of All Technologies Relative to MY2008 Passenger Cars and Light Trucks (2007 dollars)

	Baseline		Advanced Clean Cars Program	
MY	PC	LT	PC	LT
2008	$0	$0	$0	$0
2009	$203	$92	$203	$92
2010	$406	$185	$406	$185
2011	$609	$277	$609	$277
2012	$813	$369	$813	$369
2013	$893	$493	$893	$493
2014	$1,040	$681	$1,040	$681
2015	$1,449	$862	$1,449	$862
2016	$1,510	$981	$1,510	$981
2017	$1,586	$972	$1,737	$1,124
2018	$1,803	$958	$2,246	$1,199
2019	$1,655	$884	$2,553	$1,215
2020	$1,562	$866	$2,793	$1,268
2021	$1,554	$853	$3,193	$1,365
2022	$1,529	$839	$3,486	$1,423
2023	$1,492	$828	$3,714	$1,473
2024	$1,467	$820	$3,941	$1,524
2025	$1,327	$790	$3,731	$1,576
2026	$1,301	$774	$3,656	$1,544
2027	$1,275	$759	$3,583	$1,513
2028	$1,249	$744	$3,512	$1,483
2029	$1,224	$729	$3,441	$1,453
2030	$1,200	$714	$3,373	$1,424

Figure VI-8. Sensitivity of New Vehicle Sales Estimates to Vehicle Price Adjustment Assumptions



Changing the distribution of vehicle price increases suggests that the proposed Advanced Clean Cars program would result in some changes in fleet composition. As shown in Figure VI-8, total and relative new vehicle sales using C/T fleet average prices are slightly higher than they are using the overall fleet average adjustment. The attribution of ZEV costs only to passenger cars results in lower purchase prices for light trucks and subsequently higher sales. Given that passenger cars are subject to slightly more stringent criteria pollutant standards in the early years of the program, this redistribution of new vehicle sales could result in slightly higher emissions if automakers were to pass on costs in this manner. However, newer light trucks would likely have lower criteria pollutant emissions than the vehicles they are replacing, so staff believes emission benefits would continue to be positive as the overall fleet age will be lower.

Another more detailed method for adjusting vehicle attributes is to use price and operating cost adjustments based on US EPA's OMEGA model that classifies vehicles into 19 types, as defined in Table VI-10, to evaluate the effects of potentially under- or overestimating compliance costs or operating cost changes when using a simple overall fleet average value. Each vehicle configuration in the CARBITS technology attribute file was therefore assigned an OMEGA class. The matching was done using a similar attribute file provided by US EPA which included the majority of the same vehicle configurations with OMEGA classes already designated. In cases without a match—mostly future model year vehicles—an OMEGA class was manually determined by matching on number of cylinders, engine displacement and body style.

Due to the large number of adjustments needed when using OMEGA classes, the attribute file is modified in a somewhat simplified manner. Rather than adjusting prices and operating costs relative to the earlier of MY2008 or the year of introduction, adjustments were made assuming that all vehicle configurations were available in MY2008. Similar to the method described earlier, the incremental vehicle prices for each future model year shown in Table VI-11 and Table VI-12 are added to the base vehicle price while base operating costs are reduced by the corresponding percentage expected in each scenario as shown in Table VI-13 and Table VI-14. The outcome is that for vehicles introduced after MY2008, vehicle prices will be slightly higher, though operating costs will also be reduced by a slightly larger percentage.

Table VI-10. OMEGA Class Definitions

OMEGA Class	Category	Base Engine
1	Subcompact I4	1.5L 4V DOHC I4
2	Compact Car I4	2.4L 4V DOHC I4
3	Midsize Car/Small MPV (unibody) I4	2.4L 4V DOHC I4
4	Compact Car/Small MPV (unibody) V6	3.0L 4V DOHC V6
5	Midsize/Large Car V6	3.3L 4V DOHC V6
6	Midsize Car/Large Car V8	4.5L 4V DOHC V8
7	Mid-sized MPV (unibody)/Small Truck I4	2.6L 4V DOHC I4 (I5)
8	Midsize MPV (unibody)/Small Truck V6/V8	3.7L 2V SOHC V6
9	Large MPV (unibody) V6	4.0L 2V SOHC V6
10	Large MPV (unibody) V8	4.7L 2V SOHC V8
11	Large Truck (+ Van) V6	4.2L 2V SOHC V6
12	Large Truck + Large MPV V6	3.8L 2V OHV V6
13	Large Truck (+ Van) V8	5.7L 2V OHV V8
14	Large Truck (+Van) V8	5.4L 3V SOHC V8
15	Midsize MPV (unibody)/Small Truck V6/V8	5.7L 2V OHV V8
16	Large MPV (unibody) V6	3.5L 4V DOHC V6
17	Large MPV (unibody) V8	4.6L 4V DOHC V8
18	Large Truck (+ Van) V6	4.0L 4V DOHC V6
19	Large Truck (+ Van) V8	5.6L 4V DOHC V8

To provide an appropriate comparison, a similar set of results was generated maintaining the simplifying assumption that all vehicle configurations were introduced in MY2008 or earlier, but adjusting by the values shown in Table VI-12 and Table VI-14. The adjustment of attributes using the more detailed OMEGA classes shows estimates in between the other two adjustment methods, suggesting that C/T attributes may be overestimating results while the overall average attributes may be underestimating. Even though the incremental prices and percentage changes in operating costs have limited variation within a given model year, ultimately, there still remains a wide range in these attribute values because they are applied to base attributes for individual vehicle configurations that exhibit an enormous amount of variability. As the primary method of adjusting attributes produces the more conservative fleet characteristic results staff believes using the more simplified overall fleet average to be a reasonable approach, especially given that vehicle pricing will be at the discretion of individual auto manufacturers.

Note, though, that the sale of ZEVs themselves (i.e. plug-in hybrids, full battery electric vehicles, and hydrogen fuel cell vehicles) are not being explicitly projected by CARBITS, as these types of vehicles are not included among the choice alternatives. However, in the absence of knowing manufacturers pricing strategies, the primary analysis assumes that costs are evenly distributed across the entire fleet and therefore implicitly includes them in the fleet. In the event that only the compliance costs associated with internal combustion (and conventional hybrid) vehicles are passed on, the results (labeled as ICE Only Price in Figure VI-8) would be similar to assuming that only the LEV III amendments are adopted as this scenario includes very few other technology types. These results would also be indicative of future fleet composition if compliance costs are lower due to technological breakthroughs or other sources of cost reductions.

Overall, the fleet would remain younger and slightly larger in the policy scenario compared to the baseline regardless of how vehicle prices are adjusted. The assumptions made in the primary analysis produce the most conservative estimates of fleet turnover, which implies that the emissions benefits are likely to be conservative as well.

F. Summary

The results of the scenarios and sensitivity analyses show that the Advanced Clean Cars program is unlikely to result in emission increases due to changes in fleet composition. While the magnitude of emissions from light-duty vehicles in future years could fluctuate moderately due to alternative assumptions on model inputs, the overall conclusion stands that the proposed amendments will yield positive impacts on new vehicle sales and the average age of the California fleet.

Table VI-11. Baseline Incremental Vehicle Prices for All Technology Types by OMEGA Class Relative to MY2008 (2007 dollars)

OMEGA Class	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	$0	$519	$1,039	$1,558	$2,077	$2,192	$2,149	$3,223	$2,997	$3,112	$3,808	$3,497
2	$0	$243	$487	$730	$974	$822	$984	$1,350	$1,424	$1,408	$1,522	$1,398
3	$0	$67	$134	$201	$268	$175	$249	$310	$352	$415	$408	$390
4	$0	$100	$200	$300	$400	$500	$712	$921	$1,067	$1,416	$1,636	$1,478
5	$0	$97	$193	$290	$386	$509	$724	$933	$1,085	$1,082	$1,070	$957
6	$0	$83	$165	$248	$330	$411	$579	$746	$862	$845	$836	$802
7	$0	$176	$352	$528	$704	$1,050	$1,453	$1,852	$2,110	$2,154	$2,139	$1,971
8	$0	$177	$353	$530	$706	$891	$1,266	$1,628	$1,885	$1,859	$1,834	$1,679
9	$0	$174	$349	$523	$698	$885	$1,253	$1,608	$1,856	$1,832	$1,809	$1,651
10	$0	$22	$44	$67	$89	$173	$231	$289	$331	$392	$404	$380
11	$0	$7	$15	$22	$30	$38	$50	$62	$67	$66	$65	$63
12	$0	$7	$15	$22	$30	$38	$50	$62	$67	$66	$65	$63
13	$0	$80	$160	$240	$321	$413	$584	$747	$858	$846	$837	$801
14	$0	$95	$190	$285	$381	$479	$675	$863	$991	$975	$961	$917
15	$0	$43	$86	$129	$172	$230	$333	$430	$499	$524	$523	$495
16	$0	$63	$125	$188	$251	$327	$450	$566	$651	$659	$647	$586
17	$0	$98	$196	$294	$392	$442	$619	$783	$900	$868	$854	$813
18	$0	$122	$244	$367	$489	$525	$738	$936	$1,082	$1,126	$1,105	$1,006
19	$0	$89	$179	$268	$357	$457	$645	$825	$948	$934	$921	$885

OMEGA Class	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	$3,186	$3,165	$3,101	$3,014	$2,940	$2,491	$2,441	$2,392	$2,344	$2,297	$2,252
2	$1,330	$1,316	$1,295	$1,270	$1,248	$1,147	$1,124	$1,102	$1,080	$1,058	$1,037
3	$380	$378	$375	$369	$369	$355	$348	$341	$334	$327	$321
4	$1,415	$1,406	$1,386	$1,357	$1,337	$1,239	$1,214	$1,190	$1,166	$1,143	$1,120
5	$944	$933	$924	$918	$908	$886	$868	$851	$834	$817	$801
6	$791	$780	$771	$762	$755	$724	$710	$696	$682	$668	$655
7	$1,946	$1,917	$1,894	$1,873	$1,847	$1,753	$1,718	$1,684	$1,650	$1,617	$1,585
8	$1,656	$1,624	$1,602	$1,582	$1,562	$1,512	$1,482	$1,452	$1,423	$1,395	$1,367
9	$1,629	$1,598	$1,576	$1,557	$1,538	$1,491	$1,461	$1,432	$1,403	$1,375	$1,348
10	$362	$373	$371	$364	$350	$331	$325	$318	$312	$306	$300
11	$62	$61	$60	$58	$57	$56	$55	$54	$53	$52	$51
12	$62	$61	$60	$58	$57	$56	$55	$54	$53	$52	$51
13	$789	$777	$765	$756	$747	$730	$716	$701	$687	$674	$660
14	$902	$888	$874	$863	$852	$832	$815	$799	$783	$767	$752
15	$479	$483	$484	$484	$489	$479	$470	$460	$451	$442	$433
16	$578	$567	$558	$551	$548	$534	$523	$513	$503	$492	$483
17	$802	$787	$774	$764	$751	$725	$711	$696	$683	$669	$656
18	$986	$978	$965	$964	$962	$938	$919	$901	$883	$865	$848
19	$871	$858	$845	$835	$825	$802	$786	$770	$755	$740	$725

Table VI-12. Advanced Clean Cars Program Incremental Vehicle Prices for All Technology Types by OMEGA Class Relative to MY2008 (2007 dollars)

OMEGA Class	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	$0	$519	$1,039	$1,558	$2,077	$2,192	$2,149	$3,223	$2,997	$3,437	$3,851	$4,708
2	$0	$243	$487	$730	$974	$822	$984	$1,350	$1,424	$1,417	$2,849	$3,083
3	$0	$67	$134	$201	$268	$175	$249	$310	$352	$551	$937	$1,046
4	$0	$100	$200	$300	$400	$500	$712	$921	$1,067	$1,578	$2,257	$2,510
5	$0	$97	$193	$290	$386	$509	$724	$933	$1,085	$1,158	$1,292	$1,254
6	$0	$83	$165	$248	$330	$411	$579	$746	$862	$1,287	$1,754	$2,037
7	$0	$176	$352	$528	$704	$1,050	$1,453	$1,852	$2,110	$2,051	$1,998	$1,801
8	$0	$177	$353	$530	$706	$891	$1,266	$1,628	$1,885	$1,883	$1,886	$1,758
9	$0	$174	$349	$523	$698	$885	$1,253	$1,608	$1,856	$1,859	$1,864	$1,728
10	$0	$22	$44	$67	$89	$173	$231	$289	$331	$647	$1,088	$1,335
11	$0	$7	$15	$22	$30	$38	$50	$62	$67	$384	$553	$700
12	$0	$7	$15	$22	$30	$38	$50	$62	$67	$353	$507	$661
13	$0	$80	$160	$240	$321	$413	$584	$747	$858	$1,007	$1,091	$1,145
14	$0	$95	$190	$285	$381	$479	$675	$863	$991	$1,275	$1,423	$1,532
15	$0	$43	$86	$129	$172	$230	$333	$430	$499	$680	$769	$834
16	$0	$63	$125	$188	$251	$327	$450	$566	$651	$857	$958	$1,007
17	$0	$98	$196	$294	$392	$442	$619	$783	$900	$1,142	$1,276	$1,378
18	$0	$122	$244	$367	$489	$525	$738	$936	$1,082	$1,250	$1,308	$1,271
19	$0	$89	$179	$268	$357	$457	$645	$825	$948	$1,004	$1,043	$1,052

OMEGA Class	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	$5,077	$5,751	$6,185	$6,548	$6,822	$6,060	$5,939	$5,820	$5,704	$5,590	$5,478
2	$3,290	$3,671	$3,983	$4,228	$4,438	$4,134	$4,051	$3,970	$3,891	$3,813	$3,737
3	$1,198	$1,421	$1,604	$1,699	$1,869	$2,001	$1,961	$1,922	$1,884	$1,846	$1,809
4	$2,764	$3,152	$3,449	$3,656	$3,897	$3,812	$3,736	$3,661	$3,588	$3,516	$3,446
5	$1,328	$1,440	$1,531	$1,580	$1,662	$1,727	$1,692	$1,658	$1,625	$1,593	$1,561
6	$2,305	$2,736	$3,066	$3,348	$3,637	$3,796	$3,720	$3,646	$3,573	$3,501	$3,431
7	$1,730	$1,628	$1,539	$1,458	$1,382	$1,231	$1,207	$1,183	$1,159	$1,136	$1,113
8	$1,746	$1,734	$1,712	$1,691	$1,673	$1,612	$1,580	$1,548	$1,517	$1,487	$1,457
9	$1,716	$1,704	$1,685	$1,662	$1,644	$1,603	$1,571	$1,540	$1,509	$1,479	$1,449
10	$1,537	$1,834	$2,058	$2,264	$2,474	$2,572	$2,521	$2,470	$2,421	$2,373	$2,325
11	$832	$1,045	$1,192	$1,319	$1,445	$1,664	$1,631	$1,599	$1,567	$1,535	$1,505
12	$786	$986	$1,123	$1,241	$1,360	$1,553	$1,522	$1,491	$1,462	$1,432	$1,404
13	$1,203	$1,300	$1,360	$1,409	$1,460	$1,535	$1,504	$1,474	$1,444	$1,416	$1,387
14	$1,653	$1,852	$1,989	$2,104	$2,219	$2,311	$2,265	$2,219	$2,175	$2,131	$2,089
15	$893	$998	$1,062	$1,113	$1,164	$1,234	$1,210	$1,186	$1,162	$1,139	$1,116
16	$1,087	$1,218	$1,305	$1,380	$1,456	$1,554	$1,523	$1,492	$1,463	$1,433	$1,405
17	$1,488	$1,665	$1,784	$1,887	$1,992	$2,085	$2,043	$2,002	$1,962	$1,923	$1,884
18	$1,310	$1,383	$1,423	$1,453	$1,482	$1,516	$1,486	$1,456	$1,427	$1,399	$1,371
19	$1,069	$1,105	$1,118	$1,128	$1,140	$1,150	$1,127	$1,104	$1,082	$1,060	$1,039

Table VI-13. Baseline Emission Reductions for All Technology Types by OMEGA Class Relative to MY2008

OMEGA Class	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	8%	10%	12%	14%	20%	21%	21%	26%	26%	26%
2	8%	10%	0%	6%	12%	16%	17%	18%	18%	18%
3	4%	6%	7%	8%	10%	11%	13%	13%	13%	13%
4	8%	11%	12%	19%	25%	29%	30%	31%	31%	31%
5	8%	10%	13%	19%	26%	30%	31%	31%	31%	31%
6	7%	9%	8%	13%	18%	22%	22%	22%	22%	22%
7	8%	11%	15%	21%	26%	30%	31%	31%	31%	31%
8	11%	15%	23%	30%	38%	44%	44%	44%	44%	44%
9	12%	16%	16%	24%	32%	38%	38%	39%	39%	39%
10	1%	1%	-3%	-2%	-1%	-1%	1%	1%	1%	1%
11	0%	0%	-3%	-3%	-2%	-2%	-3%	-3%	-3%	-3%
12	0%	0%	-3%	-3%	-4%	-4%	-4%	-4%	-4%	-4%
13	6%	8%	8%	13%	18%	21%	22%	22%	22%	22%
14	7%	9%	9%	15%	20%	24%	24%	24%	24%	24%
15	4%	5%	6%	10%	13%	15%	17%	18%	18%	18%
16	4%	6%	10%	13%	16%	18%	18%	18%	18%	18%
17	7%	9%	10%	14%	18%	22%	22%	22%	22%	22%
18	7%	9%	8%	13%	17%	21%	22%	22%	22%	22%
19	6%	9%	10%	15%	20%	24%	24%	24%	24%	24%
OMEGA Class	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	26%	26%	26%	25%	25%	25%	25%	25%	25%	25%
2	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
3	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
4	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%
5	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%
6	22%	22%	22%	22%	22%	22%	22%	22%	22%	22%
7	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%
8	44%	44%	44%	44%	44%	44%	44%	44%	44%	44%
9	39%	39%	39%	39%	39%	39%	39%	39%	39%	39%
10	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
11	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%
12	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%
13	22%	22%	22%	22%	22%	22%	22%	22%	22%	22%
14	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%
15	18%	19%	19%	20%	20%	20%	20%	20%	20%	20%
16	18%	17%	17%	17%	18%	18%	18%	18%	18%	18%
17	22%	22%	22%	22%	22%	22%	22%	22%	22%	22%
18	22%	22%	23%	23%	23%	23%	23%	23%	23%	23%
19	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%

Table VI-14. Advanced Clean Cars Program Emission Reductions for All Technology Types by OMEGA Class Relative to MY2008

OMEGA Class	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	8%	10%	12%	14%	20%	21%	25%	30%	37%	43%
2	8%	10%	0%	6%	12%	16%	18%	25%	27%	30%
3	4%	6%	7%	8%	10%	11%	17%	20%	23%	26%
4	8%	11%	12%	19%	25%	29%	32%	35%	38%	40%
5	8%	10%	13%	19%	26%	30%	32%	33%	34%	35%
6	7%	9%	8%	13%	18%	22%	26%	28%	31%	33%
7	8%	11%	15%	21%	26%	30%	32%	33%	34%	35%
8	11%	15%	23%	30%	38%	44%	44%	44%	44%	44%
9	12%	16%	16%	24%	32%	38%	39%	39%	39%	39%
10	1%	1%	-3%	-2%	-1%	-1%	7%	11%	15%	18%
11	0%	0%	-3%	-3%	-2%	-2%	4%	7%	11%	14%
12	0%	0%	-3%	-3%	-4%	-4%	3%	6%	10%	13%
13	6%	8%	8%	13%	18%	21%	24%	25%	27%	28%
14	7%	9%	9%	15%	20%	24%	27%	29%	30%	32%
15	4%	5%	6%	10%	13%	15%	21%	23%	25%	26%
16	4%	6%	10%	13%	16%	18%	22%	23%	25%	27%
17	7%	9%	10%	14%	18%	22%	25%	27%	29%	30%
18	7%	9%	8%	13%	17%	21%	25%	26%	28%	29%
19	6%	9%	10%	15%	20%	24%	25%	25%	26%	26%
OMEGA Class	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	48%	52%	55%	58%	61%	61%	61%	61%	61%	61%
2	32%	35%	37%	38%	40%	40%	40%	40%	40%	40%
3	30%	33%	36%	39%	43%	43%	43%	43%	43%	43%
4	42%	44%	46%	48%	50%	50%	50%	50%	50%	50%
5	36%	37%	38%	39%	40%	40%	40%	40%	40%	40%
6	36%	39%	41%	44%	48%	48%	48%	48%	48%	48%
7	36%	37%	37%	38%	40%	40%	40%	40%	40%	40%
8	44%	44%	44%	44%	44%	44%	44%	44%	44%	44%
9	39%	40%	40%	40%	40%	40%	40%	40%	40%	40%
10	23%	26%	30%	33%	39%	39%	39%	39%	39%	39%
11	20%	24%	28%	32%	39%	39%	39%	39%	39%	39%
12	18%	22%	26%	29%	36%	36%	36%	36%	36%	36%
13	30%	31%	33%	34%	36%	36%	36%	36%	36%	36%
14	34%	36%	38%	40%	43%	43%	43%	43%	43%	43%
15	30%	32%	34%	36%	39%	39%	39%	39%	39%	39%
16	30%	32%	34%	37%	41%	41%	41%	41%	41%	41%
17	33%	35%	37%	39%	42%	42%	42%	42%	42%	42%
18	31%	32%	34%	35%	37%	37%	37%	37%	37%	37%
19	27%	28%	28%	29%	30%	30%	30%	30%	30%	30%

VII. Alternative Sales Impact Analysis

Staff also used an alternative approach similar to the one used by US EPA to assess the potential sales impacts of the MY2012-2016 National Program. This method uses an aggregate sales response factor, known as the price elasticity of demand, to produce a top-down estimate of potential consumer response. The price elasticity of demand is defined as the ratio of the percentage change in sales to the percentage change in price and is a frequently used measure of consumers' sensitivity to price. A typical value used in the literature and policy analysis is -1[20], meaning that the percentage decrease in new vehicle sales is equal to the percentage increase in vehicle price or vice versa.

Staff first estimated an adjustment factor in terms of a percentage change that could be applied to average increases in new vehicle prices. Assuming that all compliance costs are passed onto consumers, this increase will have additional financial implications for new vehicle buyers. Higher vehicle prices will result in an increase in loan payments for consumers who finance their purchases, as well as higher insurance premiums and registration fees. For this analysis, new vehicle buyers are assumed to own their vehicle for five years and then resell it.

The additional annual financing charges are estimated assuming an annual loan rate of 5% for five years based on the historic average of new auto loans and maturity periods collected by the Federal Reserve. The increase in purchase price and associated finance charges over the five year loan period translate into monthly payments equivalent to 1.9% of the initial price, or annual payments that are 22.6% of the initial investment. The present value of these five annual payments at a 5% discount rate results in a 2% decrease in the cost. Assuming 70% of auto purchases are financed, the same share as used in the EPA's RIA for the MY2012-2016 rule, reduces the present value to a 1.4% decrease in cost due to financing.

Insurance premiums will also increase proportional to the increase in vehicle prices. According to the Insurance Information Institute, collision and comprehensive insurance averages $464 per year (2009 dollars) in California. Relative to the California average new vehicle price of $30,295 (2009 dollars) from the California New Car Dealers Association[21], insurance premiums are 1.5% of the vehicle's value. Over the five year ownership period, the present value of these additional premiums would effectively increase the additional purchase price by 6.6%.

[20] See Kleit, Andrew, "The effect of Annual Changes in Automobile Fuel Economy Standards," Journal of Regulatory Economics, 2:2, June 1990.

[21] California New Car Dealers Association 2011 Economic Impact Report, http://www.cncda.org/secure/GetFile.aspx?ID=2106 (Accessed November 2, 2011)

Likewise, California's registration fees and sales tax are proportional to vehicle prices. Any increase in vehicle prices would be subject to a one-time sales tax of at least 7.25%.[22] Additionally, the vehicle license fee is assessed using a fixed rate of 0.65% on a declining schedule of the vehicle's value shown in Table VII-1. At a 5% discount rate, the net present value of the annual registration fees adds another 2.3% increase to the initial vehicle price.

Table VII-1. California Vehicle License Fee Calculations

Year	Percent of Purchase Price Used for Assessing VLF	Annual Registration (% of Purchase Price)
1	100%	-0.65%
2	90%	-0.59%
3	80%	-0.52%
4	70%	-0.46%
5	60%	-0.39%

Source: California Revenue and Taxation Code Section 10752.1 and 10753.2

However, higher new vehicle prices also generally results in higher resale values, which may offset some or all of the increases. Based on used vehicle values from the National Automobile Dealers Association, on average a new vehicle still retains 50% of its value after five years. Assuming that depreciation rates are constant regardless of initial purchase price, higher vehicle prices would translate to higher resale values. Discounted to a present value at a 5% discount rate, this translates to a benefit worth 39% of the incremental vehicle price.

Thus, the net effect on consumer expenditures resulting from increased vehicle prices would be the sum of the sales tax (7.25%), vehicle license fee (2.3%), additional insurance premiums (6.6%), additional finance charges (-1.4%), and additional resale value (-39%), so that any incremental vehicle prices would be adjusted by a factor of 75.6% assuming a 5% discount rate. Using a 3% discount rate increases the adjustment factor slightly to 76.1%, while a 7% discount rate lowers the adjustment factor to 75.0%. The use of higher auto loan rates or lower resale values would increase the adjustment factor more substantially, though these changes would need to be rather extreme (greater than 20% interest rate for a five year loan, or less than 15% resale value for a five-year old vehicle) to increase the factor significantly above 100%.

[22] 7.25% reflects the base California sales tax rate. Local governments may impose additional taxes to bring the rate closer to 10% in some areas. However, given the large variability in sales tax rates throughout the state as well as the fact that consumers do not necessarily need to purchase a vehicle near where they live, staff used the minimum state base sales tax rate for its analysis.

The adjustment factor 75.6% is applied to the overall fleet average incremental vehicle price for compliance with the baseline and proposed Advanced Clean Cars scenarios; the difference between the two scenarios results in the adjusted prices shown in Column (B) of Table VII-2. However, consumers would also expect reduced operated costs from these vehicles. US EPA previously assumed that consumers will value five years' worth of fuel savings, an assumption that was validated by the National Automobile Dealers Association in their public comment letter. Discounting these savings to present value at a 5% discount rate produces the values shown in Column (C). The adjusted price change shown in Column (D) is calculated by subtracting Column (C) from Column (B). Dividing the values in Column (D) by the average price of a new MY2015 vehicle results in the percentage changes shown in Column (E). The average price of a new MY2015 vehicle was estimated by adding the incremental vehicle price for MY2015 vehicles in the baseline scenario to the current average new vehicle price from the California New Car Dealers Association, to yield a projected MY2015 vehicle price of $31,255 (2009 dollars). The negative values imply that the operating cost savings and higher resale values after five years far outweigh ownership costs and any additional compliance costs.

As a result of the net savings, the price of new vehicles declines with time relative to a base MY2015 new vehicle. Applying the elasticity value of -1 to the resulting percentage change in vehicles prices implies that new vehicle sales would increase by 0 to 4.9 percent from MY2015 to MY2025 as shown in Column (F). The percentage changes in new vehicle sales shown are consistent with those projected by CARBITS relative to MY2015 levels.

Using a 3% discount rate results in a 5.4% increase in new vehicle sales in 2025 while assuming a 7% discount rate results in a 4.5% increase. If consumers value only four years' worth of fuel savings, new vehicle sales increases would be 3.5% in 2025, which is the highest level over the 2015-2025 timeframe. Valuing the fuel savings for only three years would further dampen sales, though they would still remain positive ranging from 0% for MY2015 to 1.8% for MY2025. A three-year valuation would imply savings ranging from $0 to $2000 for MY2015-2025 discounted at a rate of 5%; even capping consumer valuation of savings to $1500 would still exceed the adjusted incremental vehicle price so that sales would be largely unaffected, if not grow by a small amount.

Unlike the CARBITS approach, this simplified approach applies only to new vehicle sales and does not provide any insights into the changes in fleet size or average vehicle age that could occur from the regulations. Additionally, this elasticity approach does not take into consideration any of the variation in consumer preferences or household characteristics that may influence demand for new vehicles.

Table VII-2. Advanced Clean Cars Price Elasticity of Demand

(A) MY	(B) Adjusted Incremental Vehicle Price (2009 dollars)	(C) Operating Cost Savings over Five Years (2009 dollars)	(D) Adjusted Price Change Net of Fuel Savings (2009 dollars)	(E) % Change in Net Price	(F) % New Sales Change
2015	$4	$3	$0	0.0%	0.0%
2016	$11	$5	$6	0.0%	0.0%
2017	$135	$403	-$268	-0.9%	0.9%
2018	$309	$649	-$341	-1.1%	1.1%
2019	$559	$993	-$434	-1.4%	1.4%
2020	$744	$1,280	-$536	-1.7%	1.7%
2021	$974	$1,676	-$701	-2.2%	2.2%
2022	$1,153	$1,987	-$833	-2.7%	2.7%
2023	$1,302	$2,268	-$965	-3.1%	3.1%
2024	$1,447	$2,537	-$1,090	-3.5%	3.5%
2025	$1,445	$2,991	-$1,546	-4.9%	4.9%

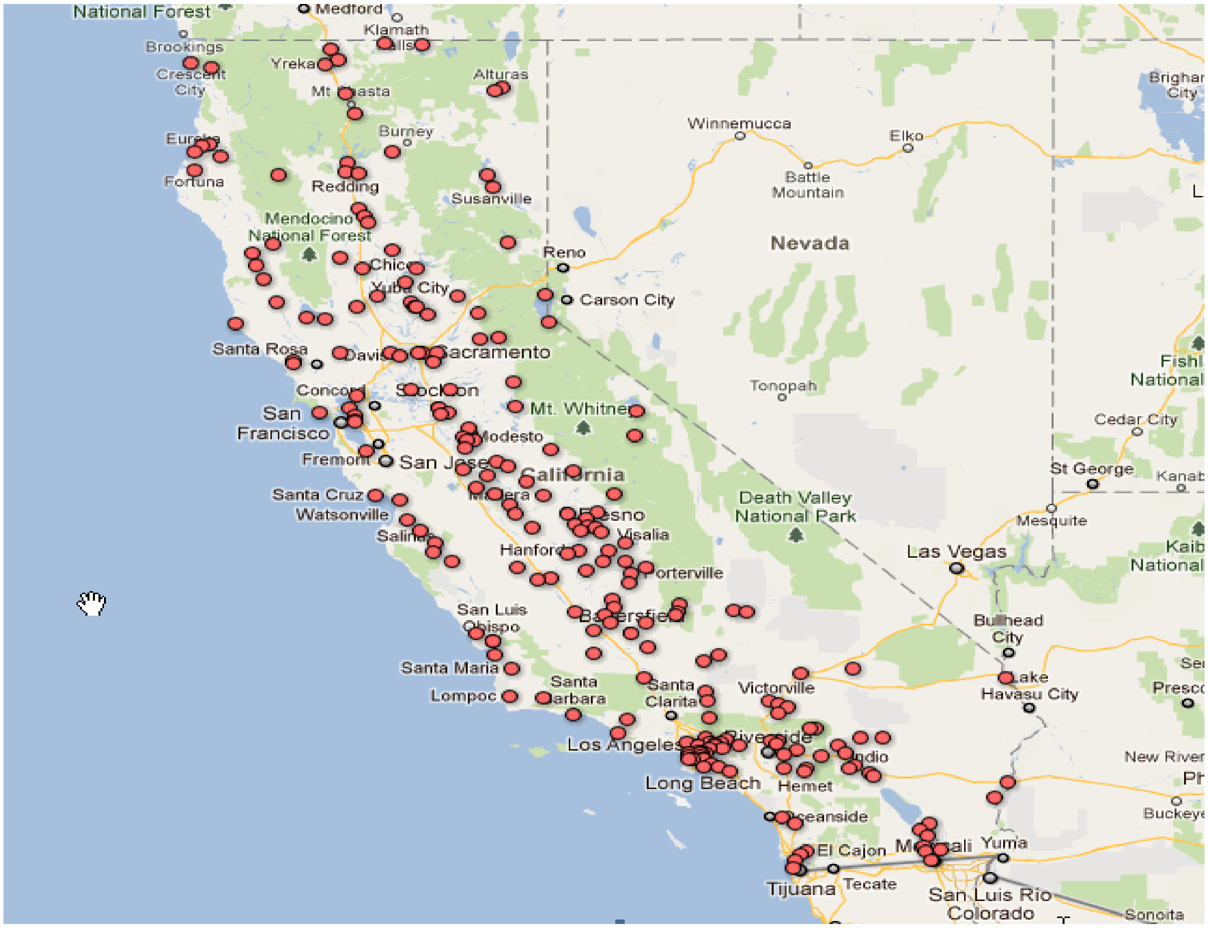
Note: Columns may not sum exactly due to rounding.

VIII. Economic Impact on Affiliated Businesses in Low-Income Cities in California

This section evaluates potential economic impacts that the proposed clean car regulations may have on low-income cities in California. Low-income cities in California were identified from the 2005-2009 American Community Survey[23]. The survey conducted by the US Census Bureau estimates the poverty level for all cities in California. According to the survey, the average poverty level in California was 13.2 percent in 2009. All California cities whose poverty levels were at or over 13.2 percent were considered to be low-income cities. Out of 1,067 cities identified by the survey, 422 had the poverty level of 13.2 percent or more. The low-income cities were home to approximately 15 million Californians or about 41 percent of the California population in 2009. Of these 15 million Californians, 2.9 million or 19 percent were considered to be low-income. Figure VIII-1 shows the locations of low-income cities on the California map.

[23]http://www.dof.ca.gov/research/demographic/state_census_data_center/american_community_survey/view.php

Figure VIII-1. Low-Income Cities in California



A. Affiliated Businesses

Section 43018.5 (E) of the California Health and Safety code requires an assessment of the impact of the proposed clean car regulations on businesses affiliated with the auto industry, especially those located in low-income communities. **Error! Not a valid bookmark self-reference.** provides a list of the auto-related industries that we were able to identify to represent affiliated businesses. These businesses fall into twenty-three standard industrial classifications (SIC). Socio-economic data were obtained from Dun and Bradstreet Market Insight (MI) database.[24]

Socio-economic data, however, were not available for all low-income cities and affected businesses. These data were adjusted to account for missing data assuming that missing data have the same distribution as the available data. First, the data were adjusted to reflect the socio-economic data for the entire population of low-income cities in California. The D&B MI data were only available for 320 cities out of the 422 low-

[24] Market Insight is a propriety subscription-based business intelligence database provided by Dun and Bradstreet Corporation.

income cities. These cities were home to more than 92 percent of population living in all low-income cities in California. Second, the D&B MI data were adjusted to reflect employment and sales data for all affected businesses. Employment data were available for 95 percent of businesses and sales data for 86 percent of businesses.

Table VIII-1. Socioeconomic Profile of the Auto Affiliated Industries

SIC Code	Industry	Number of Businesses	Total Employment	Total Sales (million in 2009 $)
3011	Tires Manufacturing	27	316	26.9
3711	Motor Vehicles & Car Bodies	87	1,319	129.9
3714	Motor Vehicles Parts	320	5,383	739.2
5012	Automobiles & Other Vehicles	491	3,539	433.6
5013	Vehicle Supplies & New Parts	1,662	12,977	1,469.7
5014	Tires & Tubes	445	2,630	404.9
5015	Motor Vehicle Parts, Used	299	1,780	191.3
5511	New & Used Car Dealers	2,177	36,418	8,634.3
5521	Used Car Dealers	1,944	7,033	1,241.1
5531	Auto Supply Stores	4,174	26,375	1,530.1
5541	Gasoline Service Stations	3,277	23,347	5,481.1
7514	Passenger Car Rental	890	5,715	234.1
7515	Passenger Car Leasing	83	857	56.8
7532	Body Repair Shops	3,307	16,739	1,247.8
7533	Exhaust System Repair Shops	881	2,592	183.7
7534	Tire Retreading Shops	184	819	77.2
7536	Glass Replacement Shops	459	1,295	72.3
7537	Transmission repair shops	692	2,421	181.1
7538	General Auto Repair Shops	8,776	26,793	2,315.1
7539	Automotive Repair Shops, NEC	2,385	10,504	577.3
7542	Carwashes	1,774	9,258	407.1
7549	Automotive services, NEC	2,810	12,623	1,196.3
Total		37,144	210,733	26,830.9

Source: Dun and Bradstreet Market Insight Database, Dun and Bradstreet data were adjusted to reflect employment and sales data for all businesses.

As shown in the above table, staff identified 37,144 businesses in low-income cities in California. These businesses employed over 210,000 people and generate about $27 billion in annual sales. These businesses, in aggregate, generated sales of about $127,000 per employee.

B. Study Approach

The approach used to evaluate the potential economic impact of the proposed Advanced Clean Cars program on affiliated businesses is outlined as follows:

(1) Changes in revenues caused by the proposed regulations for each affiliated industry were estimated.

(2) Three year average (2007-2009) profitability ratios published by Dun and Bradstreet[25] are used to estimate the impact on profitability of affiliated businesses.

C. Sales-to-employment ratios are calculated from the information in Affiliated Businesses

Section 43018.5 (E) of the California Health and Safety code requires an assessment of the impact of the proposed clean car regulations on businesses affiliated with the auto industry, especially those located in low-income communities. **Error! Not a valid bookmark self-reference.** provides a list of the auto-related industries that we were able to identify to represent affiliated businesses. These businesses fall into twenty-three standard industrial classifications (SIC). Socio-economic data were obtained from Dun and Bradstreet Market Insight (MI) database.

Socio-economic data, however, were not available for all low-income cities and affected businesses. These data were adjusted to account for missing data assuming that missing data have the same distribution as the available data. First, the data were adjusted to reflect the socio-economic data for the entire population of low-income cities in California. The D&B MI data were only available for 320 cities out of the 422 low-income cities. These cities were home to more than 92 percent of population living in all low-income cities in California. Second, the D&B MI data were adjusted to reflect employment and sales data for all affected businesses. Employment data were available for 95 percent of businesses and sales data for 86 percent of businesses.

(3) Table VIII-1.

(4) These ratios are used to estimate the impact on employment in each affected industry.

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[25] Industry Norms and Key Business Ratios, One Year desktop Edition, Dun and Bradstreet, 2010.

(5) This analysis represents a static approach. This approach provides an estimate of the immediate change caused by the regulation and does not account for long-term changes such as growth in population; employment; vehicle miles traveled (VMT), etc. Although this approach usually tends to overestimate the immediate impact a regulation, it's an appropriate approach, because of simplicity, when the impact of a regulation is small.

D. Assumptions

The proposed Advanced Clean Cars regulations are likely to require changes in vehicle technology that could increase the price of vehicles sold in California. However, the new technology may also reduce energy intensity, resulting in a reduction in driving costs. Given this scenario is most likely to occur, staff estimated the potential economic impacts of the proposed regulations on affiliated businesses based on the following assumptions:

(1) The proposed regulations would result in an average increase of $1,900 in the price of a new vehicle. However, as discussed in Section IX.B, additional purchasing costs would be more than offset by fuel savings, resulting in a net price reduction of 5 percent for a MY2025 vehicle.

(2) New vehicle sales increase by 5 percent as a result of a net reduction in vehicle prices. Correspondingly, sales of old vehicles fall by 5 percent.

(3) Liquid fuel usage will decline by 13 percent in 2025. However, affected service stations are expected to increase their sales of hydrogen fuel by $170 million in 2025.

(4) Fuel sales falls by 25 percent, assuming fuel prices would not change from the current level.

(5) Demand for automotive services and repairs decreases by 5 percent proportional to the increase in sales of new vehicles, assuming that new vehicles require less services than old vehicles.

These assumptions are for the illustration purpose and may not be applicable to all businesses. The estimated impact tends to be on the high side because we made a conservative assumption of no growth in affected businesses.

E. Potential Impacts on Affiliated Businesses

Affiliated businesses in low-income cities are affected by the proposed clean car regulations to the extent that implementation of the regulations would change their profitability. Using the above assumptions, staff estimated the impact on profitability of affiliated businesses. As shown in Table VIII-2, the impact on profitability would be the most severe for gasoline service stations. The affected service stations would experience an estimated decline of almost $740 million in revenues and about $6.4 million in profits. No change is expected on the profitability of new automotive dealers. The gain in profit associated with the 5 percent increase in sales volume is estimated to be roughly equivalent with the decrease in profit associated with the 5 percent reduction in vehicle prices. The profitability impact on manufacturers of automotive parts and bodies would be positive but that on auto repair shops would be negative.

Table VIII-2. Impact on Profitability of Affiliated Businesses (2009 dollars)

Industry	Changes in Revenues	Profit as % of Revenues	Changes in Profitability
Tires Manufacturing	$1,345,000	2.3	$31,383
Motor Vehicles & Car Bodies	$6,495,000	2.3	$151,550
Motor Vehicles Parts	$36,960,000	1.2	$137,321
Automobiles & Other Vehicles	$0	1.2	$0
Vehicle Supplies & New Parts	$0	1.6	$0
Tires & Tubes	$0	1.4	$0
Motor Vehicle Parts, Used	($9,565,000)	1.4	($137,098)
New & Used Car Dealers	$431,715,000	0.8	$3,453,720
Used Car Dealers	($62,055,000)	1.3	($827,400)
Auto Supply Stores	$0	1.3	$0
Gasoline Service Stations	($542,543,000)	0.6	($3,436,106)
Passenger Car Rental	$0	1.7	$0
Passenger Car Leasing	$0	1.7	$0
Body Repair Shops	$0	1.6	$0
Exhaust System Repair Shops	($9,185,000)	1.2	($107,158)
Tire Retreading Shops	($3,860,000)	1.2	($45,033)
Glass Replacement Shops	($3,615,000)	1.2	($42,175)
Transmission repair shops	($9,055,000)	1.2	($105,642)
General Auto Repair Shops	($115,755,000)	1.2	($1,350,475)
Automotive Repair Shops, NEC	($28,865,000)	3.2	($914,058)
Carwashes	$0	1.3	$0
Automotive services, NEC	$0	4.9	$0
Net Impact	($739,698,000)		($6,351,012)

F. Potential Impact on Employment

Table VIII-3 provides ratios of revenue per employee and per business for affected industries with affiliated businesses. For example, a typical service station in low-income cities earns about $1.7 million in revenues annually or $235,000 per employee. On average, a typical affiliated business generated about $722,000 in revenues per year or about $127,000 per employee.

Table VIII-3. Affiliated Businesses' Revenue Per Employee and Per Business (2009 dollars)

Industry	Revenue Per Employee	Revenue Per Business
Tires Manufacturing	$85,127	$996,296
Motor Vehicles & Car Bodies	$98,484	$1,493,103
Motor Vehicles Parts	$137,321	$2,310,000
Automobiles & Other Vehicles	$122,520	$883,096
Vehicle Supplies & New Parts	$113,254	$884,296
Tires & Tubes	$153,954	$909,888
Motor Vehicle Parts, Used	$107,472	$639,799
New & Used Car Dealers	$237,089	$3,966,146
Used Car Dealers	$176,468	$638,426
Auto Supply Stores	$58,013	$366,579
Gasoline Service Stations	$234,767	$1,672,597
Passenger Car Rental	$40,962	$263,034
Passenger Car Leasing	$66,278	$684,337
Body Repair Shops	$74,544	$377,321
Exhaust System Repair Shops	$70,872	$208,513
Tire Retreading Shops	$94,261	$419,565
Glass Replacement Shops	$55,830	$157,516
Transmission repair shops	$74,804	$261,705
General Auto Repair Shops	$86,407	$263,799
Automotive Repair Shops, NEC	$54,960	$242,055
Carwashes	$43,973	$229,481
Automotive services, NEC	$94,771	$425,730
Typical Business	$127,322	$722,348

Table VIII-4 provides an assessment of the impact of the proposed regulations on jobs and affiliated businesses in low-income cities in California. As shown in the table, service stations are expected to lose approximately 2,300 jobs, used car and part dealers about 440 jobs and auto repair shops about 2,200 jobs as a result of the proposed regulations. These job losses, however, are likely to be offset partially by the creation of 350 jobs by manufacturers of auto body and parts. Furthermore, they accounted for less 0.1 of one percent of all jobs in low-income cities in California. According to the D&B MI, there were over 6.5 million employed in low-income cities in California in 2009.

It should be noted here that our analysis represents a partial equilibrium evaluation of the impact of the proposed regulations on affiliated businesses. The analysis does not include the positive impact of the proposed regulations on unaffiliated businesses. As described in Section VII, the reduction in fuel consumption is expected to save consumers a significant amount of money. Part of the consumer savings is likely to be spent on non-liquid fuel such as electricity and the balance will be spent on other consumer products and services. Depending upon where the consumers direct their expenditures, many unaffiliated businesses will benefit from the proposed regulations. Because of higher average economic multipliers of unaffiliated sectors relative to service stations and repair shops, staff believes the numbers of jobs created by these businesses significantly exceed the number of jobs lost from service stations and auto repair shops.

Table VIII-4. Net Impact of the Proposed Regulations on Jobs and Affiliated Businesses

Industry	Job Gain (Loss)	Business Creation (Elimination)
Tires Manufacturing	16	1
Motor Vehicles & Car Bodies	66	4
Motor Vehicles Parts	269	16
Automobiles & Other Vehicles	0	0
Vehicle Supplies & New Parts	0	0
Tires & Tubes	0	0
Motor Vehicle Parts, Used	(89)	(15)
New & Used Car Dealers	0	0
Used Car Dealers	(352)	(97)
Auto Supply Stores	0	0
Gasoline Service Stations	(2,311)	(324)
Passenger Car Rental	0	0
Passenger Car Leasing	0	0
Body Repair Shops	0	0
Exhaust System Repair Shops	(130)	(44)
Tire Retreading Shops	(41)	(9)
Glass Replacement Shops	(65)	(23)
Transmission repair shops	(121)	(35)
General Auto Repair Shops	(1,340)	(439)
Automotive Repair Shops, NEC	(525)	(119)
Carwashes	0	0
Automotive services, NEC	0	0
Net Impact	(4,622)	(1,084)

G. Potential Impact on Business Creation, Expansion, and Elimination

As shown in Table VIII-4, the proposed regulations are estimated to result in the equivalent elimination of 324 service stations, 112 used car and part dealers and 669 auto repair shops in low-income cities in California while 21 auto body and parts manufacturers are created. The loss of these businesses would reduce the number of businesses in low-income cities by less than 0.1 of one percent. According to the D&B MI, there were over 1.2 million businesses of all kinds in low-income cities in California in 2009.

The proposed regulations are also expected to result in the creation or expansion of numerous unaffiliated businesses, depending upon where the consumers redirect their savings from the reduction in fuel consumption and repair costs. Note that this analysis represents a static approach that assumes no growth in population, employment, VMT, etc. Section V shows that the proposed amendments could lead to a very slight increase in demand for travel that would increase the demand for gasoline and reduce the impact on service stations from what is anticipated here. Nonetheless even without growth, overall the number of businesses created or expanded in California is expected to exceed the number of businesses eliminated.

H. Potential Impact on Business Competitiveness

Affiliated businesses are mostly local businesses. These businesses mostly compete against each other and are not subject to competition from out-of-state businesses. Therefore, the proposed regulations are not expected to impose significant competitive disadvantages on affiliated businesses.

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